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CHAIN GRATE STOKERS

THE
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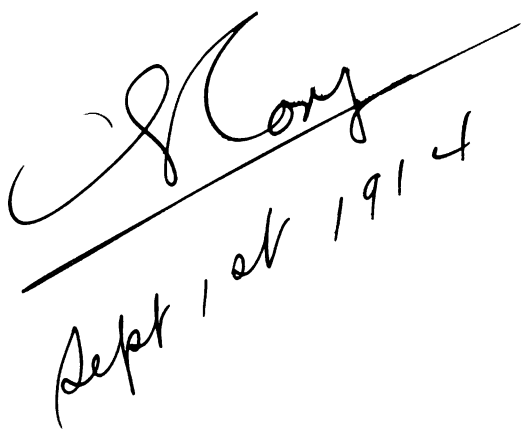

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CHAIN GRATE STOKERS

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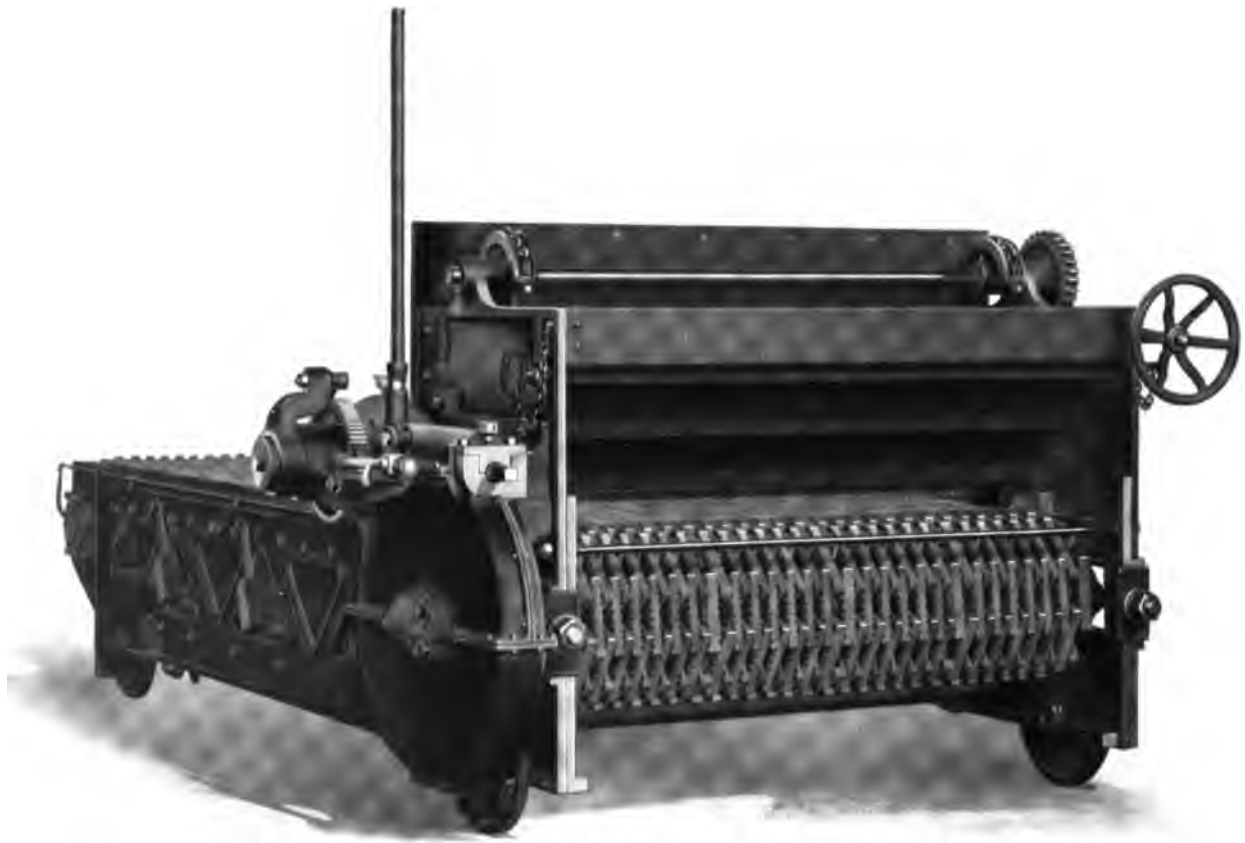

BABCOCK & WILCOX CHAIN GRATE STOKER

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AUTOMATIC STOKERS

WITH the modern tendency toward increased overloads, high efficiencies, and smokeless combustion, there has come an enormous increase in the field of usefulness for the automatic stoker.

Inasmuch as the capacity of a properly designed boiler is limited almost entirely by the amount of fuel that may be burned in its furnace, and as combustion rates may be secured with an automatic stoker which cannot be approached by ordinary hand-firing methods, the increased capacity to be obtained from a given amount of heating surface with a stoker-fired over a hand-fired furnace is an obvious advantage.

Increased efficiency is another of the important advantages of the stoker-fired over the hand-fired boiler. With such an apparatus it is possible to make use of a poorer grade of coal with an efficiency as high or higher than that obtained with better grades of fuel in hand-fired furnaces. Such an increase in efficiency is the result of the even and continuous firing of an automatic stoker as against the intermittent firing of the hand-fired furnace, and a constant air supply as against variation in this supply with the changing furnace conditions which cannot be avoided in hand-fired practice. Still another cause for the increase in efficiency is the almost complete absence of the necessity for working the fires. When properly proportioned stokers and furnaces are operated in connection with a well-designed boiler, the capacity obtainable may be increased without the loss of efficiency at the higher ratings which would accompany such an increase with hand-fired furnaces.

The labor saving resulting from the installation of such an apparatus is a large item in a properly designed plant. This is a feature, however, that must be considered from several aspects. It is true that a stoker feeds coal to the fire automatically, but if this coal has to be fed first to the stoker hopper by hand, much of its automatic advantage is lost. This is also true of the handling of the ash from such an installation. When coal and ash-handling apparatus is not installed, there is no saving in labor. In large plants, however, stokers, used in conjunction with the modern methods of coal storage and coal and ash handling, make possible a large labor saving. In small plants the labor saving effected by the use of stokers is negligible, while the expense of the installation is no less proportionately than in large plants.

While the question of smoke and smokeless combustion is largely one of degree, and certain conditions may arise under which any furnace may cause smoke, it may be safely stated that a stoker-fired plant, under ordinary operating conditions, is much more nearly smokeless than one which is hand fired. This is due to the same causes as are given above for the increase in efficiency possible with stoker-fired boilers over hand fired, namely, those features leading to the better combustion that may be secured where stokers are used.

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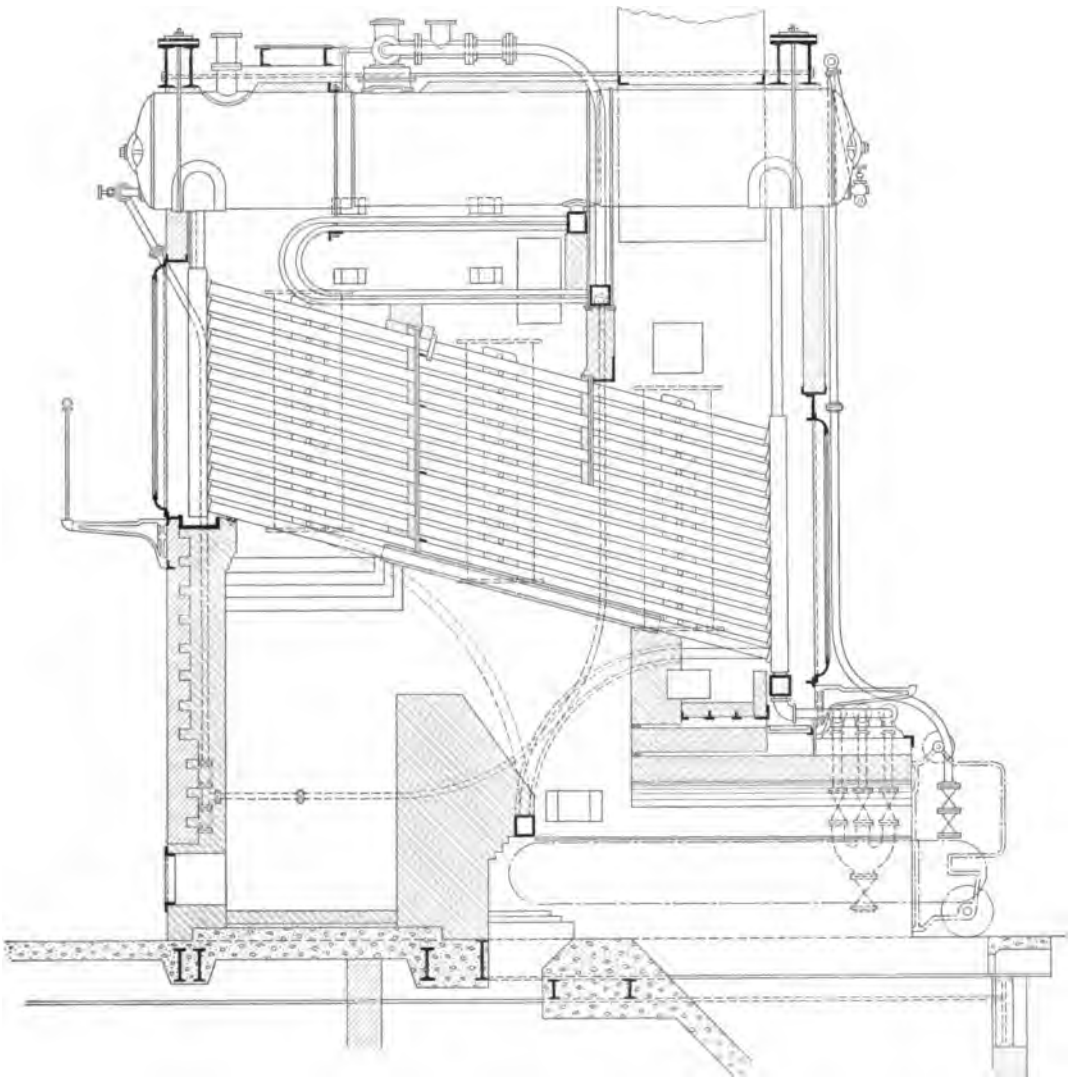

BABCOCK & WILCOX CHAIN GRATE STOKER INSTALLED WITH BABCOCK & WILCOX BOILER—A SETTING WHICH HAS BEEN PARTICULARLY SUCCESSFUL IN MINIMIZING SMOKE

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Against the advantages resulting from the use of automatic stokers there are several features that must be considered in determining the wisdom of making such an installation.

The cost of stokers is greatly in excess of the cost of hand-fired furnaces. Due to the higher capacities at which stoker-fired boilers are ordinarily operated, the upkeep cost of the furnace is greater than in hand-fired practice. This applies not only to the upkeep cost of the stoker proper, but also to that of the furnace brickwork. From their greater first cost and the more severe nature of the service that stokers are required to meet, the depreciation will obviously be greater than in the case of hand-fired furnace material.

Automatic stokers require a higher degree of intelligence on the part of the operating crew than do hand-fired furnaces, but such an objection is largely overcome by the present-day tendency toward the employment of a better class of labor in the boiler room. An early objection to stokers in general had its basis in the fact that the ash contained an excessive amount of unburned carbon. This objection also has been largely overcome by improvements in design of practically all stokers.

From this brief statement of advantages and disadvantages, it is obvious that the question of the advisability of a stoker installation is one which must be considered most carefully in all of its phases. The added efficiency and capacity, the labor saving possible, and the smokelessness must be balanced against the added first cost or interest on the investment, the depreciation and maintenance cost, the steam required for stoker drive or blast, and the added cost of furnace upkeep.

In general, a stoker installation will be found profitable in the larger plants properly equipped for handling the fuel and ashes. In small plants such an installation may be advisable only where the question of smokeless combustion is paramount.

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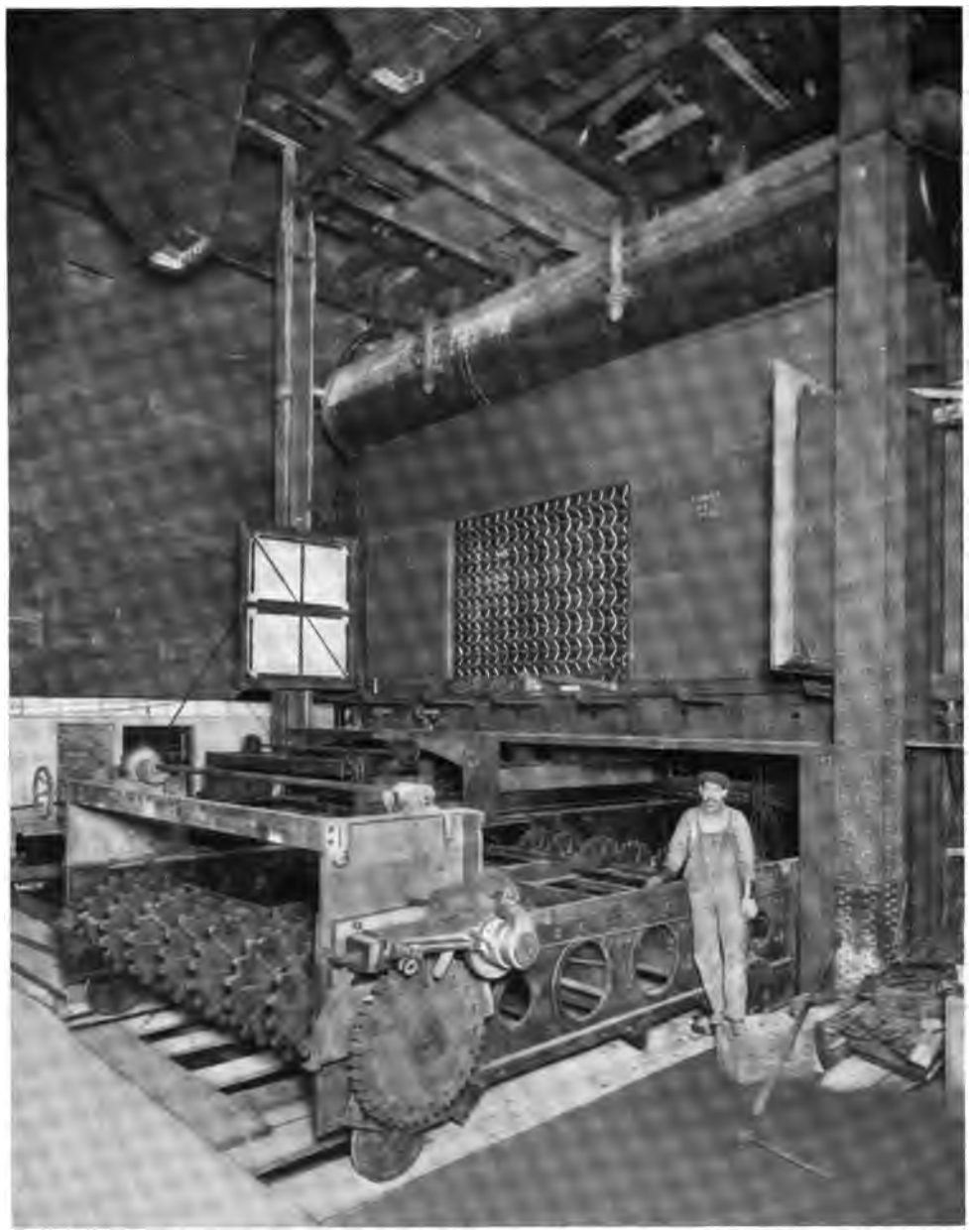

TWO BABCOCK & WILCOX CHAIN GRATE STOKERS IN COURSE OF ERECTION WITH A 1220 HORSE-POWER BABCOCK & WILCOX BOILER AT THE FISK ST. STATION OF THE COMMONWEALTH EDISON CO., CHICAGO, ILL.

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ADVANTAGES OF CHAIN GRATE STOKERS

AUTOMATIC stokers may be divided into three general classes—the underfeed, the overfeed, and the traveling grate. In efficiency of combustion, other conditions being equal, there will be no appreciable difference with the different types of stoker, provided that the proper type is selected for the grade of fuel used and the conditions of operations to be fulfilled. No stoker will satisfactorily handle all classes of fuel, and in making a selection care must be taken to suit the type to the fuel and the operating conditions of the service to be performed.

That the chain grate stoker more fully meets the requirements of automatic firing than do other types is exemplified by the fact that there are more manufacturers turning out this class of apparatus than any other class of stoker. Further, in European practice, particularly in Great Britain and Germany where the highest possible efficiencies are sought, the chain grate stoker is used to the almost entire exclusion of other types of stoker.

In this country the field of usefulness of the chain grate stoker has been, up to the present time, largely confined to the burning of the more highly volatile coals of the Middle West. With such coals, chain grates have given the most satisfactory service—efficiencies and capacities being secured that are among the highest on record—and this, oftentimes, with coals that could not be handled satisfactorily on other types of stoker.

More recently, attention has been given to the adaptation of this type of stoker to the burning of the less volatile coals with results which are eminently satisfactory and full of promise for the future of the stoker with this class of fuel.

Chain grate stokers are not new, having been one of the first types of apparatus offered for automatically feeding coal to a boiler furnace. In the general design and operation of the chain grate stoker, there are a number of features that give it a distinct advantage over other types. In operation the fuel is fed uniformly to the forward end of the grate, the volatile gases are distilled on this portion, and passing over the incandescent fuel bed are fully consumed. The progress of the fuel from the green coal at the front of the furnace to incandescent coke and finally to ash at the rear of the grate is uniform and continuous. This progressive combustion prevents the sudden liberation of a large volume of gas such as would occur where a shovelful of green coal is fired by hand upon the top of an incandescent bed of fuel.

The grate is in the form of a chain, of which approximately only one-third is under the fire at one time. With most coals, and assuming that proper draft conditions obtain, or that there is a suction available in the boiler furnace under all conditions, the small portion of the grate under the fire and the continual change of such portion gives ample provision for cooling. The grate, formed as

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COMMONWEALTH EDISON CO., CHICAGO, ILL. TWO UNITS IN THE FISK STREET STATION. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 59,700 HORSE POWER OF BABCOCK & WILCOX BOILERS IN THIS STATION THE COMMONWEALTH EDISON CO., HAS BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 101,600 HORSE POWER OF BABCOCK & WILCOX BOILERS IN ITS VARIOUS STATIONS

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it is of relatively short links, presents a flat surface to the fire and permits none of the links to extend into the fire. These features lead to a long life of the grate and the renewal of the grate bars or links becomes a negligible factor instead of a controlling feature, as is the case in some other forms of stoker. The long life of a chain grate is perhaps best exemplified by the fact that there are stokers of this description which have been in operation for over fifteen years on the links of which the casting marks are still plainly visible.

With the chain grate, the automatic phase of feeding is carried to a higher point than is possible with most other types of stoker. Not only is the feed continuous, as is the case in practically all stokers, but the cleaning of the fires is continuous. Reference has already been made to the almost entire absence of the necessity of working the fires but practically all types of stokers, except chain grates, require some definite cleaning period, resulting usually from the necessity of dumping auxiliary flat or coking grates. At such times the furnace conditions approach closely those of the cleaning periods in hand-fired practice, with the consequent losses in efficiency and periodic intervals of smoking. Chain grate stokers on the other hand are being cleaned continuously by the passage of the ash over the rear of the grates and the furnace conditions are not varied by having to dump the ash and shake down the fires at the cleaning intervals. While such cleaning periods with other stokers may be far apart, still their necessity causes a lowering of the average of furnace efficiency in a long run. The automatic cleaning of a chain grate fire, on the other hand, enables test conditions in the furnace to be maintained over any period of time required.

The maintenance cost of chain grate stokers is, in most instances, considerably less than that of other types. The grates are the only portion exposed to the fire, and it has been pointed out that with most coals and proper draft conditions ample provision is made for their cooling. As it is practically impossible with adequate draft to burn out any part of the stoker, the maintenance cost of this type of apparatus is reduced to a minimum. Chain grate stokers from the nature of their operation are comparatively easy on the furnace brickwork, and here, again, the maintenance expense is low as compared with that where other types of stokers are used.

From the continuous cleaning it is clear that with proper operation the furnace will be practically smokeless at all times.

A distinct advantage of this class of stoker is the fact that the entire stoker may be readily removed from the furnace for inspection or repair without in any way disturbing the setting or the boiler, while with other types, for such removal, the stoker must be dismantled.

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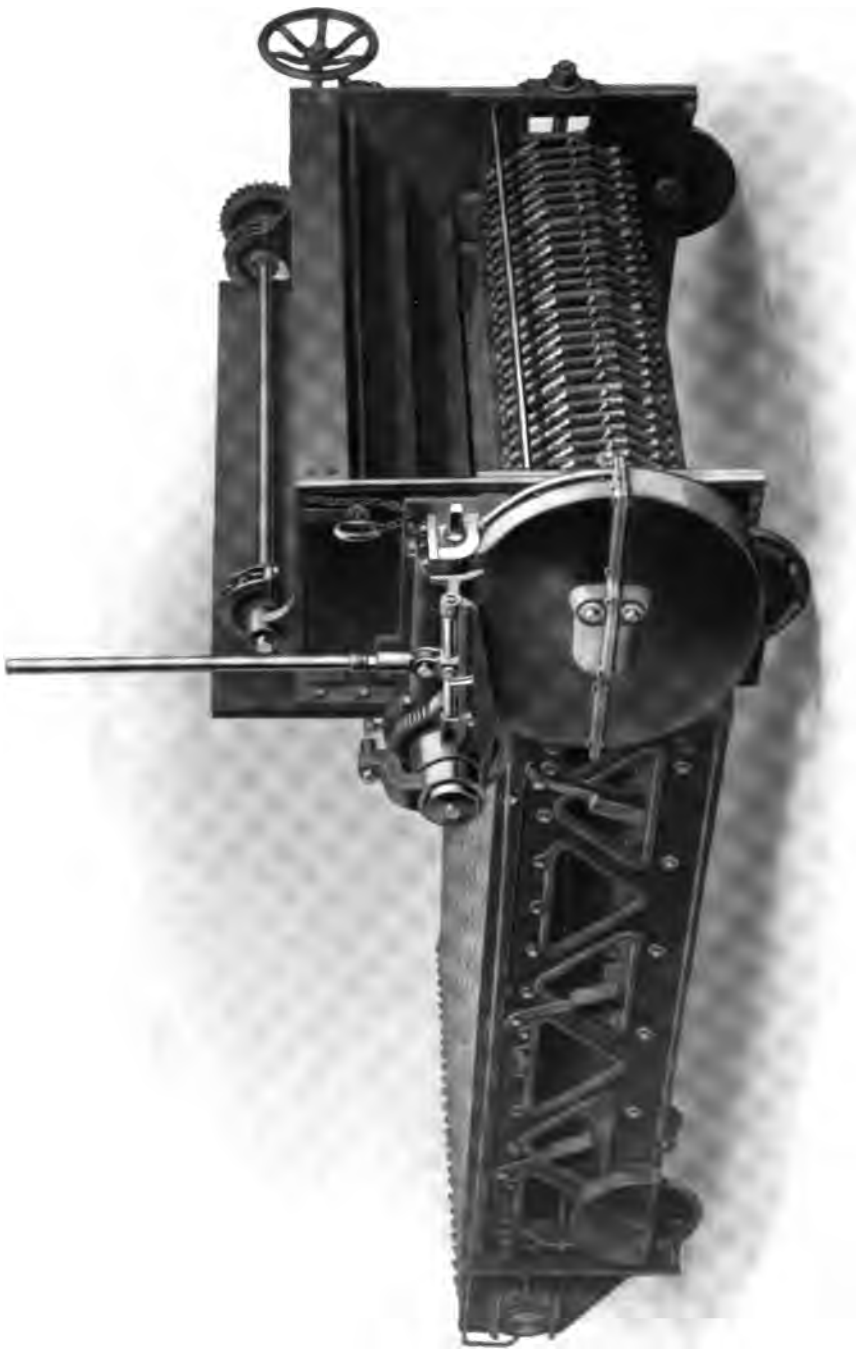

BABCOCK & WILCOX CHAIN GRATE STOKER. THREE-QUARTER FRONT VIEW

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THE BABCOCK & WILCOX CHAIN GRATE STOKER

THE advantages of the chain grate stoker as a class have been pointed out. The success of an individual stoker of this class, however, is dependent upon the care exercised in the details of its design and construction to obviate difficulties to which improper attention to such features would lead.

The care necessary in such details to secure the successful operation of this class of stoker is, apart from the description of the apparatus as a whole, perhaps best illustrated by certain specific features embodied in the Babcock & Wilcox chain grate stoker.

A bridge wall water box is supplied as a regular part of the stoker equipment.

Where a proper bridge wall water box is not supplied as a part of the stoker, trouble is bound to arise from the leakage of air at the rear of the furnace. The brickwork of the bridge wall becomes eroded, leaving large irregular holes for the admission of air. Combustion has been completed by the time the fire has reached this point and any further admission of air simply dilutes the products of combustion and increases the loss in the stack gases.

Further, a bridge wall water box acts as a protection to the links of the grate. These links in starting to turn over the rear sprocket, break from the flat surface of the grate and their corners extend upward. With the bridge wall water box so placed that such an action of the links takes place after they have passed its face, there is no danger of burning these projecting corners.

Efficient side seals are provided.

Without proper side seals a large leakage of air will occur at the sides of the furnace with a resulting effect on the efficiency of the boiler as bad as through leakage at the rear of the grate. In either case, such leakage chokes all gas passages, flue and stack, decreases the draft and lowers the amount of air drawn through the fuel bed, with the consequent reduction of capacity and economy of the boiler.

The construction of the stoker as a whole is of such a rugged nature as to allow continuous operation without shutting down for repairs, over long periods of time. Such a feature is obviously a necessity if the stoker is to be considered a commercial success.

The following detailed description of the Babcock & Wilcox chain grate stoker, together with a study of the accompanying illustrations, will indicate the reasons for the particular success with which it has met the requirements of a good stoker as above outlined.

The grate proper is made up of common and driving links, the latter being $\frac{3}{8}$ inch wider than the former at the hub, both links being 4 inches deep. The links of any row are held together by a steel rod passing through their hubs. These links are machine molded with greatest accuracy from metal patterns, and

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BABCOCK & WILCOX CHAIN GRATE STOKER. THREE-QUARTER REAR VIEW

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no variation in excess of $\frac{1}{64}$ inch is tolerated. The faces of the links are $\frac{1}{16}$ inch narrower than the hubs, thus giving a space of $\frac{1}{8}$ inch between adjacent links sidewise for the admission of air. Half-round grooves are cast in the sides of the links for increasing the air space, these grooves being so arranged that they cannot come opposite to each other in adjacent links.

The chain passes over sprocket wheels of large diameter at the front and rear of the grate, these being keyed to a steel shaft of ample diameter. The shafts run in solid cast-iron machined bearings of generous proportions which are mounted in rectangular guides at the rear of the cast-iron side frames, and in the cast-iron sections or cheek pieces which are bolted to these frames at the front. Adjustment is provided by means of large diameter screws for both front and rear bearings. Such adjustment makes possible the taking up of any sag in the chain or allows removal of any link without dissembling the whole stoker. Compression grease cups for lubrication of these bearings are located at the stoker front and are piped to front and rear bearings.

The upper part of the chain is supported on rollers spaced 9 inches apart, and the lower portion on rollers spaced 18 inches apart. These rollers are of wrought-iron pipe, to the ends of which cast-iron bushings are fitted. The bushings run on stationary wrought-steel axles extending from side to side of the grate and supported by the cast-iron frames.

Side Frames — The side frames are of heavy cast-iron construction with diagonal web members, which make them unusually strong as beams, and at the same time afford ample access to the space between the upper and lower chain. These frames are $3\frac{1}{2}$ inches wide at the top and present an upper surface flush with the top of the grate. The inner sides of the flush portions are machined and form a guide against which the side links of the chain rub. At the outer edges of the side frames, side seals are held by guide bolts which allow them a vertical motion. These seals are held by weighted levers against the under surface of cast-iron side plates which are built into the brick-work and overhang the side frames of the stoker.

The vertical motion of these seals allows the complete exclusion of air at the sides of the furnace and the fire in this way is kept from burning out at the sides. This motion also permits the side seals to be depressed when, for any reason, it is necessary to withdraw the stoker.

To the front of the frame proper cast-iron cheek pieces are bolted, these forming the extension which projects beyond the furnace front line.

The side frames and cheek pieces are maintained at a proper distance from each other by means of steel spacing bolts front and rear, a cast-iron cross beam at the front, which also maintains the cheek pieces in a vertical position, a wrought-steel channel at the front of the cheek, a second wrought-steel channel between the chains at the front, and a third wrought-steel channel between the chains at the rear.

This last wrought-steel channel forms a part of the baffle at the rear of the stoker for excluding the air from this space. Below the channel a steel plate

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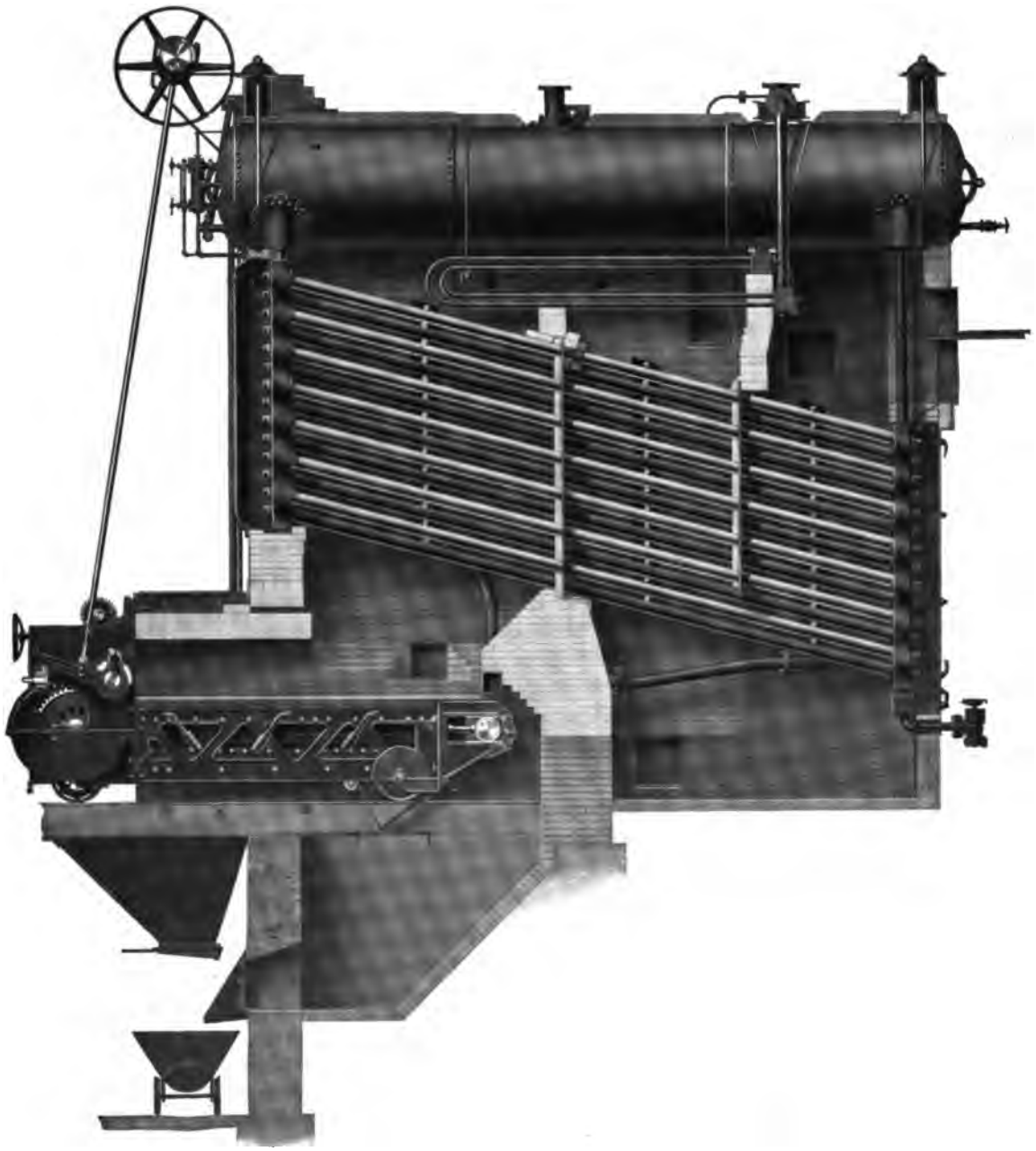

BABCOCK & WILCOX CHAIN GRATE STOKER INSTALLED WITH A WROUGHT-STEEL VERTICAL HEADER BOILER, EQUIPPED WITH A BABCOCK & WILCOX SUPERHEATER

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baffle stiffened by angles forms an additional spacing piece. Hinged to the bottom of this stationary baffle plate a swinging steel plate, stiffened by angles, extends to the bottom of the ashpit between the stoker rails completing the seal at the rear. A chain connected to this hinged baffle is brought to the front of the stoker where it may be fastened. By this means the baffle may be held in any position and a greater or less amount of air admitted at the rear to meet the varying conditions of combustion. When this large damper is raised it affords easy access to the rear of the stoker without withdrawing it from the furnace.

Diagonal rods from side to side maintain the frames at right angles to the cross ties and shafts.

TRACK WHEELS—The track wheels are of heavy cast iron, 18 inches in diameter, running on steel axles. These axles are tight in the wheels and revolve in machined bearings at either side of the wheel, the bearings being integral with the frames and front cheeks of the stoker.

RAILS—Stoker rails are furnished as a part of the standard stoker equipment. These are heavy angles to which guide strips are riveted and are of sufficient length to enable the stoker to be entirely drawn from the furnace.

COAL HOPPER—A coal hopper of large capacity is formed at the front by the cast-iron side cheeks of the stoker and by an inclined steel sheet stiffened by angles. The lower edge of this plate is supported by lugs cast on the inner faces of the stoker cheeks, and the upper edge is supported by removable pins through these side cheeks. The pins are attached to the side cheeks by chains and have large enclosed handles by which they can be readily withdrawn. The whole is so arranged that by the withdrawal of these pins the plate may be allowed to drop and any coal in the stoker hopper and the fire itself may be quickly drawn out onto the boiler room floor, if for any reason such action is necessary.

STOKER COAL GATE—A coal gate, sliding vertically in removable guides bolted to the inner surface of the cast-iron cheek pieces, furnishes a method of regulating the thickness of the fuel bed as fed to the forward end of the grate. The height of this gate is regulated by a hand wheel through a worm wheel and cross shaft, which raises or lowers the chains from which the gate is hung. The inner surface of this gate is lined with fire brick which may be removed as occasion demands without interfering with the operation of the stoker.

STOKER DRIVE—The front sprocket shaft is driven by a heavy cast-iron worm wheel. This worm wheel engages a cast-iron worm secured by fitted taper keys to a worm shaft, the outer end of which is squared, and to the inner end of which is keyed one of a pair of mitre gears. Another mitre gear which engages this is actuated by a ratchet wheel. Long and short tool steel pawls drive this ratchet wheel from a cast-iron ratchet arm. A second pair of tool steel pawls prevents the ratchet wheel from moving backward. The pawls referred to in each case differ in length by an amount equal to one-half of a tooth of the ratchet wheel, with the result that a fineness of feed is possible equivalent

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DRIVING MECHANISM OF BABCOCK & WILCOX CHAIN GRATE STOKER WITH CASING REMOVED

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to that of a ratchet wheel with twice the number of teeth of that supplied, without the disadvantage of fine teeth on this wheel.

The bearings for the driving mechanism are supported by cast-iron frames bolted to one cheek piece.

The driving mechanism as a whole is completely encased with a cast-iron housing which gives effectual protection to these parts and by preventing the accumulation of coal dust on such parts assures the absence of wear from this cause.

The ratchet arm referred to is driven from an eccentric rod, the radius of whose attachment to the ratchet arm may be changed at will to increase or decrease the amount of feed for each revolution of the eccentric. A spring safety stop in the eccentric rod limits the power which may be transmitted from the eccentric, to prevent breakage in case any foreign object blocks the motion of the stoker.

STOKER DRIVE WITH CASING REMOVED—FRONT VIEW

By simply lifting the pawls out of engagement with the ratchet wheel and applying a crank to the squared end of the worm shaft, the grate may be run in or out by hand. It is one of the requirements in the erection of the stoker that one man be able to operate the grate in either direction with this crank before any power is applied.

STOKER WATER BOX—A stoker water box is a part of the standard stoker equipment. At the bridge wall, such a bridge wall water box of forged steel, 7¼ inches square outside, is carried transversely across the end of the stoker. The water box acts as an air seal at this point, limits the thickness of the bed of consumed fuel which may pass under it, prevents the admission of large quantities of air around the end of the grate, and by acting as a means of solidifying the rear of the fire, prevents an uneven admission of air through this portion of the fuel bed.

This water box is connected into the circulation of the boiler, requiring no other provision for keeping it cool. The exit connection from the box is made in a position which will completely drain the box of any steam which may form within it, and the possibility of overheating is avoided by the positive circulation

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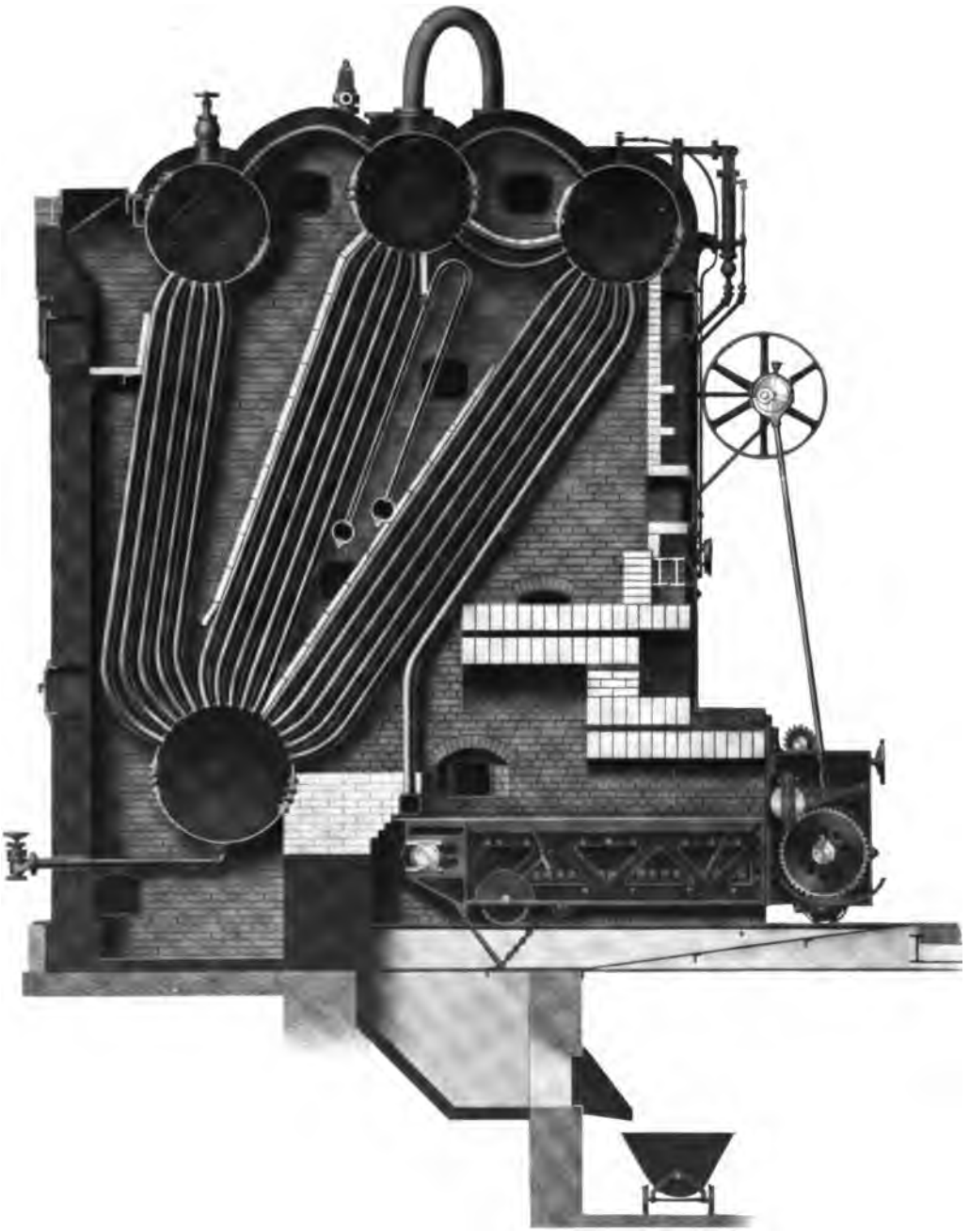

BABCOCK & WILCOX CHAIN GRATE STOKER INSTALLED WITH A STIRLING BOILER, EQUIPPED WITH A BABCOCK & WILCOX SUPERHEATER

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maintained. The exposed surface of the box is active in the absorption of heat and the losses entailed by a separate circulation for cooling are avoided.

The connections to and from the stoker water box are made by boiler tubes expanded into counterbored seats. Provision is made for internal inspection of the box by supplying handholes through which the joints may be re-expanded if such a course should for any reason be necessary.

LUBRICATION — Ample provision is made for lubricating all bearings. The drive housing, which has been described, is partially filled with oil, thus keeping the teeth of the driving wheel slushed at all times.

WORKMANSHIP AND MATERIAL — Materials entering into the construction of the stoker are of the best procurable for the duty to be performed, and the workmanship in its building is of the highest class.

Bearings which are subject to slow motion and heavy pressure are between machine steel and machined cast-iron surfaces, which experience has shown to give the best service. Bearings on the worm shaft are babbited. Bronze thrust collars are provided for receiving the thrust of the worm. Bearings for the coal gate operating device are machined. All machining is done with jigs and templates so that repair parts are interchangeable.

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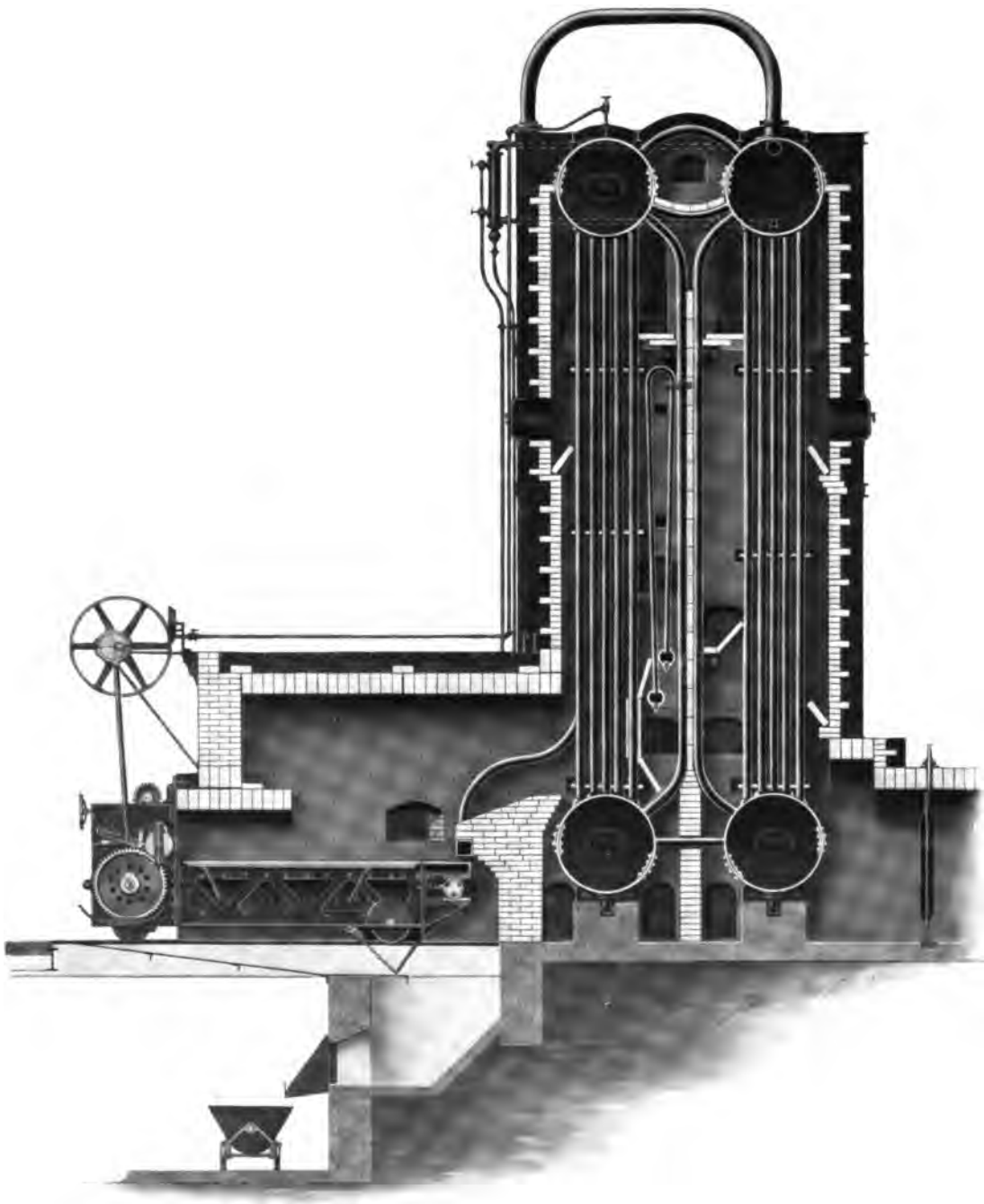

BABCOCK & WILCOX CHAIN GRATE STOKER INSTALLED WITH A RUST BOILER, EQUIPPED WITH A BABCOCK & WILCOX SUPERHEATER

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THE BABCOCK & WILCOX CHAIN GRATE STOKER IN SERVICE

THE Babcock & Wilcox chain grate stoker was first commercially manufactured in 1893. Its performance since that time with the coals, for which experience has shown it is particularly adapted, has given eminent satisfaction in plants operating under widely varying conditions of load. This is perhaps best exemplified by the large number of repeat orders received for the apparatus.

Continuous operation has shown that the upkeep cost of the stoker iron work is remarkably low and, where properly operated, is practically negligible. As an example, it may be cited that in certain power stations, where the service is the most severe that can be found in boiler operating practice, there are stokers that have been operated continuously for over fifteen years, on the links of which the original casting marks are still plainly visible, and the upkeep cost of the iron work of these stokers has been considerably less than $50.00 per stoker, or less than $3.00 per stoker per year. The long life and low maintenance cost are due, as has been indicated, to the inherent advantages of the chain grate stoker as a class, and particularly the rugged construction of the Babcock & Wilcox stoker as representative of the type.

The appended table of tests* indicates the efficiences and capacities that may be obtained from different boilers when set with Babcock & Wilcox chain grate stokers. In considering the figures presented in this table it is to be remembered that while they represent test conditions, such conditions may be more closely approached in operating practice with the chain grate stoker than with any other type of stoker, and that because of the continuous and efficient cleaning of the fires, such results may be obtained over indefinite periods of time and are not limited to tests of but a few hours' duration.

* See pages 41 to 47.

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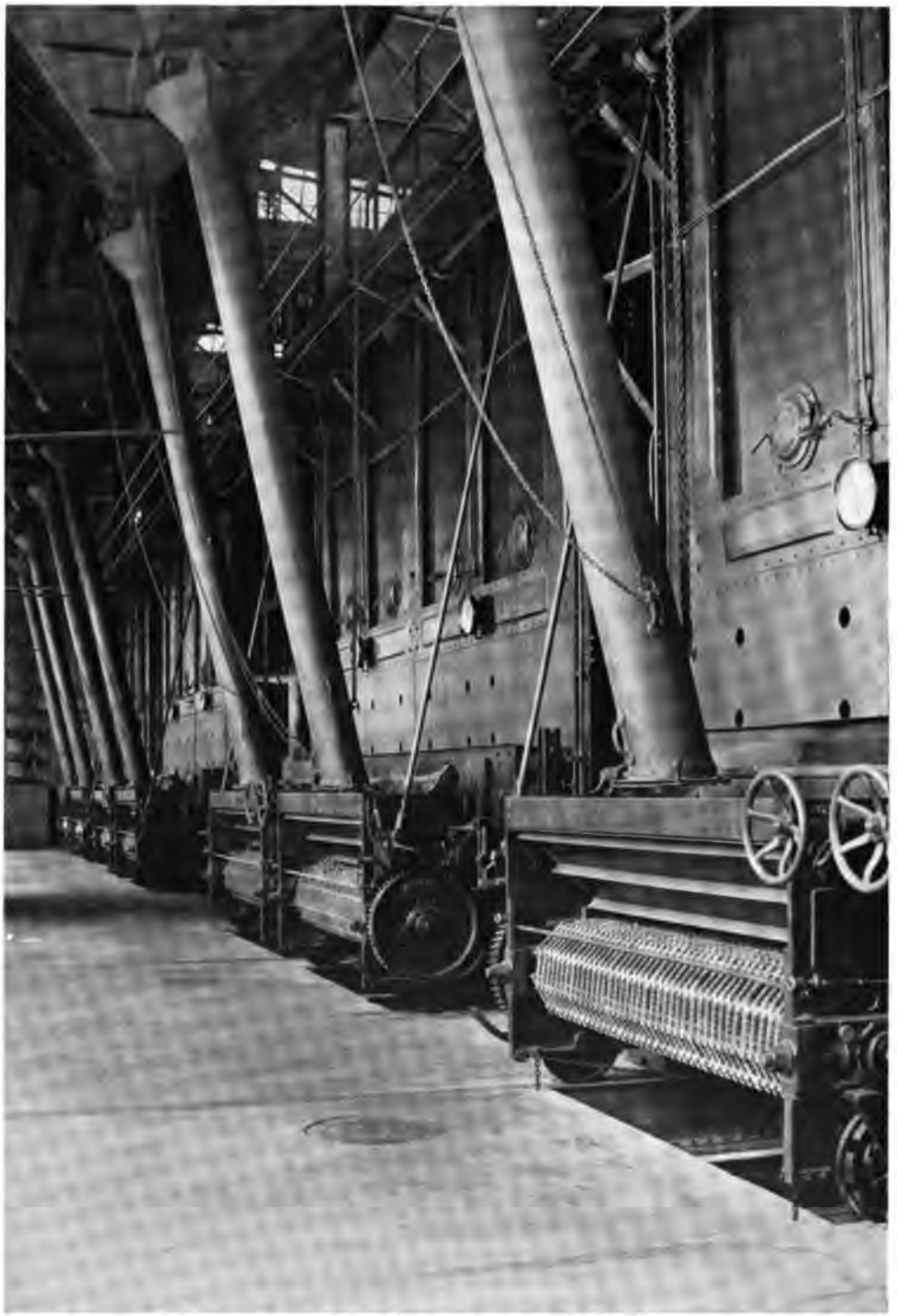

EDWARD FORD PLATE GLASS CO., ROSSFORD, OHIO. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 4000 HORSE POWER OF STIRLING BOILERS

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STOKER-FIRED FURNACE BRICKWORK

THE consideration of brickwork for stoker-fired furnaces may be divided into three parts, namely: furnace design, quality of brick used, and workmanship in the laying up of brick. The question as here considered is limited to the furnace proper, and deals, therefore, only with fire brick.

DESIGN — The design of the furnace is obviously of the greatest importance. Such design, however, varies so widely with different types of boilers and stokers, different fuels, and different operating conditions that no general statement that will apply to all cases may be made as to what constitutes a proper furnace design. The number of combinations possible of boilers, stokers, fuels and operating conditions is so very extensive that no attempt will be made here to suggest a furnace design. Each individual installation of boiler and stoker should be considered by itself and the furnace design based upon experience as to what has given the most satisfactory service for a similar set of conditions.

QUALITY OF FIRE BRICK —The modern tendency toward high overloads has increased greatly the severity of the service under which furnace brickwork is called upon to stand, and to a very great extent the life of the furnace is dependent upon the quality of fire brick entering into its construction.

Until very recently, the important characteristic upon which to base a judgment of the suitability of fire brick for use in connection with boiler settings has been considered the melting point, or the temperature at which the brick will liquify and run. Experience has shown, however, that this point is only important within certain limits and that the real basis upon which to judge material of this description is, from the boiler man's standpoint, the quality of plasticity* under a given load. This tendency of a brick to become plastic occurs at a temperature much below the melting point and to a degree that may cause the brick to become deformed under the stress to which it is subjected. The allowable plastic or softening temperature will naturally be relative and dependent upon the stress to be endured.

With the plasticity the determining factor, the perfect fire brick is one whose critical point of plasticity lies well above the working temperature of the fire. It is probable that there are but few brick on the market which would not show, if tested, this critical temperature, at the stress met with in arch construction, at a

* A method of testing brick for this characteristic is given in the Technologic Paper No. 7 of the Bureau of Standards dealing with "The Testing of Clay Refractories, with Special Reference to Their Load Carrying Capacity at Furnace Temperatures." Referring to the test for this specific characteristic, this publication recommends the following: "When subjected to the load test in a manner substantially as described in this bulletin, at 1350 degrees centigrade (2462 degrees Fahrenheit), and under a load of 50 pounds per square inch, a standard fire brick tested on end should show no serious deformation and should not be compressed more than one inch, referred to the standard length of nine inches."

In the Bureau of Standards Test for softening temperature, or critical temperature of plasticity under the specified load, the brick are tested on end. In testing fire brick for boiler purposes a better method is that of testing the brick as a beam subjected to its own weight and not on end. This method has been used for years in Germany and is recommended by the highest authorities in ceramics. It takes into account the failure of tension in the brick as well as by compression and thus covers the tension element which is important in arch construction.

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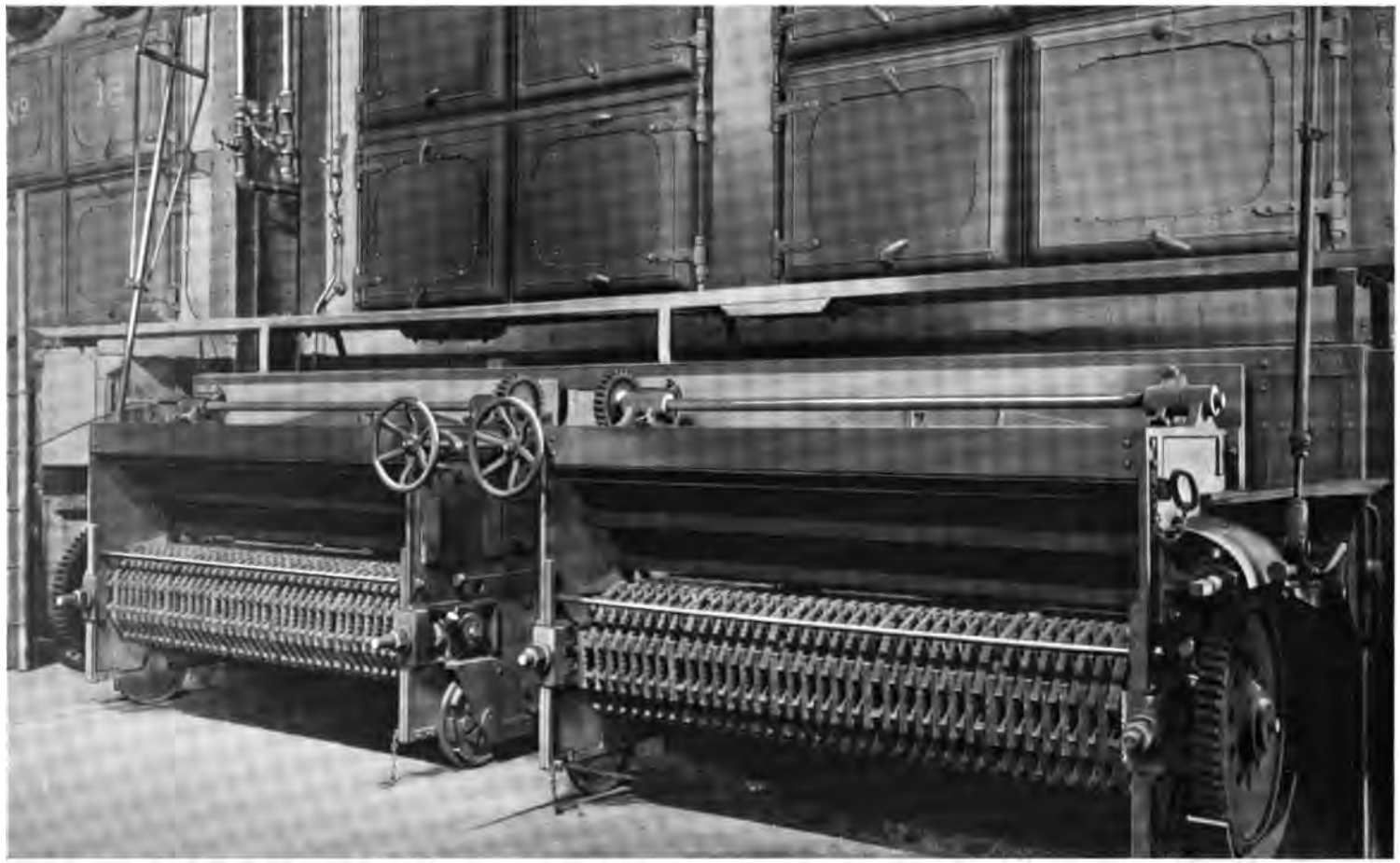

BILLINGS SUGAR CO., BILLINGS, MONT. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 700 HORSE POWER OF BABCOCK & WILCOX BOILERS

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point less than 2400 degrees. The fact that an arch will stand for a long period under furnace temperatures considerably above this point is due entirely to the fact that its temperature as a whole is far below the furnace temperature and only about 10 per cent of its cross section nearest the fire approaches the furnace temperature. This is borne out by the fact that arches which are heated on both sides to the full temperature of the ordinary furnace will first bow down in the middle and eventually fall.

The plastic point under a unit stress of 100 pounds per square inch, which may be taken as the maximum arch stress, should be above 2800 degrees to give perfect results and should be above 2400 degrees to enable the brick to be used with any degree of satisfaction.

The other characteristics by which the quality of a fire brick is to be judged are:

FUSION POINT — In view of the fact that the critical temperature of plasticity is below the fusion point, this is only important as an indication from high fusion point of a high temperature of plasticity.

HARDNESS — This is a relative quality based on an arbitrary scale of 10 and is an indication of probable cracking and spalling. Provided hardness is sufficient to enable the brick to withstand its load, additional hardness is a detriment rather than an advantage.

EXPANSION — The lineal expansion per brick in inches. This characteristic in conjunction with hardness is a measure of the physical movement of the brick as affecting a mass of brickwork, such movement resulting in cracked walls, etc. The expansion will vary between wide limits in different brick and provided such expansion is not in excess of, say, .05 inch in a 9-inch brick, when measured at 2600 degrees, it is not particularly important in a properly designed furnace, though in general the smaller the expansion the better.

COMPRESSION — The strength necessary to cause crushing on the brick at the center of the 4¼-inch face by a steel block one inch square. The compression should ordinarily be low, a suggested standard being that a brick show signs of crushing at 7500 pounds.

SIZE OF NODULES — The average size of flint grains when the brick is carefully crushed. The scale of these sizes may be taken: Small, size of anthracite rice; large, size of anthracite pea.

RATIO OF NODULES — The percentage of a given volume occupied by the flint grains. This scale may be considered: High, 90 to 100 per cent; medium, 50 to 90 per cent; low, 10 to 50 per cent.

The statement of characteristics suggested as desirable, are for arch purposes where the hardest service is met. For side wall purposes the compression and hardness limit may be raised considerably and the plastic point lowered.

From the nature of fire brick their value can only be considered from a relative standpoint. Generally speaking, what are known as first-grade fire brick may be divided into three classes, though only the first two are ordinarily considered suitable for stoker work. Table 1 gives the characteristics of these two classes,

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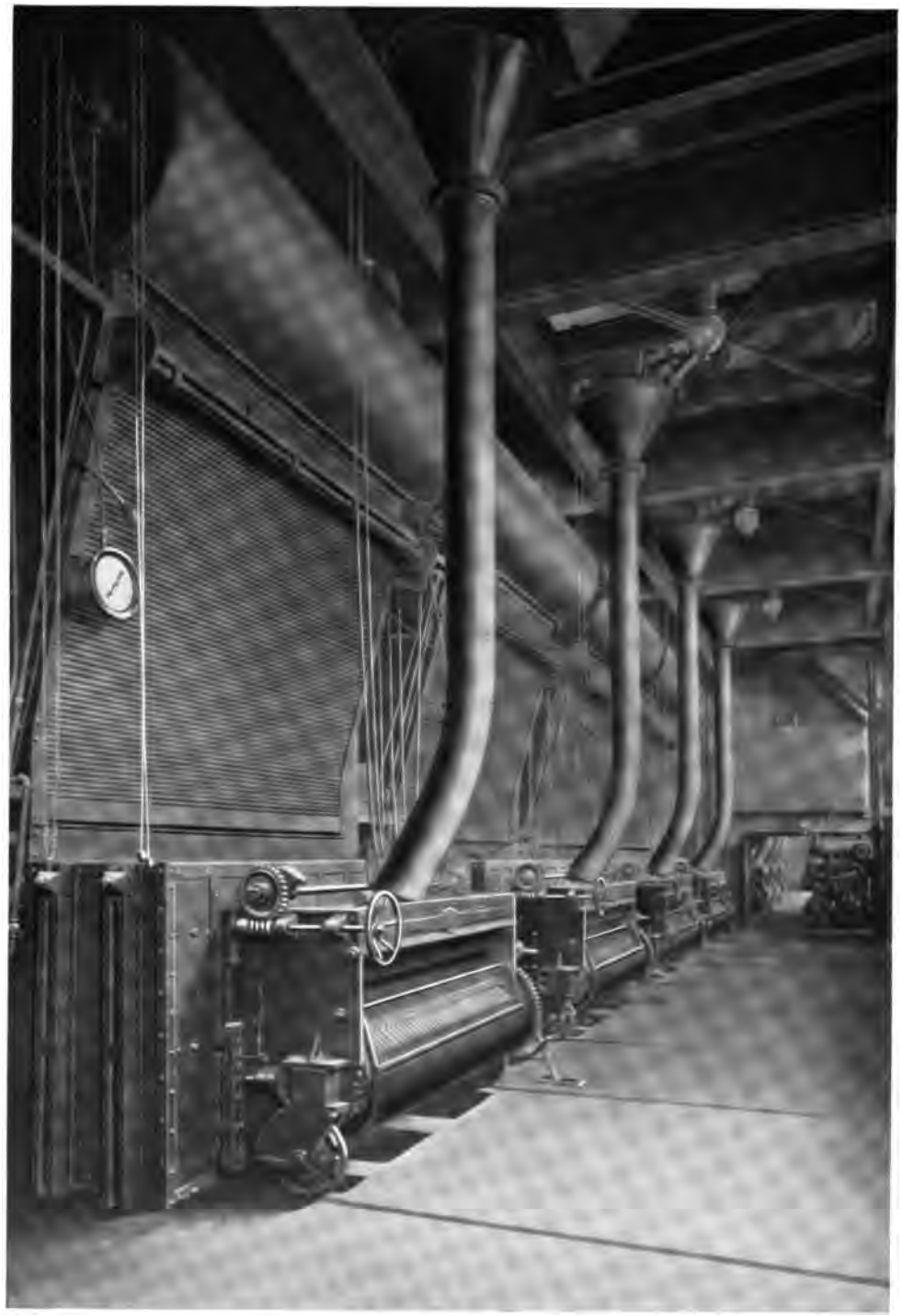

WASHINGTON TERMINAL CO., WASHINGTON, D. C. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 3000 HORSE POWER OF CROSS DRUM BABCOCK & WILCOX BOILERS

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Class A being for stoker-fired furnaces where high overloads are to be expected or other extreme conditions of service are apt to occur, and Class B being for stoker settings where it is known that no excessive overloads will be required.

TABLE 1

Characteristics	Class A	Class B
Fuse point, degrees Fahrenheit	Safe at 3200–3300 deg. F.	Safe at 2900–3200 deg. F.
Compression, pounds	6500–7500	7500–11,000
Hardness, relative	1–2	2–4
Size of nodules	Medium	Medium to medium large
Ratio of nodules	High	Medium to high

An approximate determination of the quality of a fire brick may be made from the appearance of a fracture. Where such a fracture is open, clean, white and flinty, the brick in all probability is of a good quality. If this fracture has the fine uniform texture of bread, the brick is probably poor.

In considering the heavy duty of brick in boiler furnaces, experience shows that arches are ordinarily the cause of trouble. These may fail from the following causes:

Bad workmanship in laying up of the brick. This feature is treated later.

The tendency of brick to become plastic at a temperature below the fusing point. The limits of allowable temperature have been shown.

SPALLING—This action occurs on the inner ends of combustion arches where they are swept by gases at a high velocity at the full furnace temperature. The most troublesome spalling arises from cold air striking the heated brickwork. Inasmuch as rapid temperature changes are to a great degree eliminated in stoker-fired work, this cause of failure is less frequent than formerly. Furthermore, there are a number of brick on the market practically free from such defects and where a new brick is considered it can be tried out and discarded if the defect is found to exist.

FAILURE FROM THE EXPANSIVE POWER OF BRICK is also rare, due to the fact that there are a number of brick in which the expansion is well within the allowable limits and the ease with which such defects may be determined before a brick is used.

FAILURE THROUGH CHEMICAL DISINTEGRATION — Failure through this cause is found only occasionally in brick containing a high percentage of iron oxide.

With the grade of brick selected best suited to the service of the boiler to be set, the other factor affecting the life of the setting is the laying. It is probable that more setting difficulties arise from the improper workmanship in the laying up of brick than from poor material, and to insure a setting which will have even a reasonable life it is necessary that the masonry work be done

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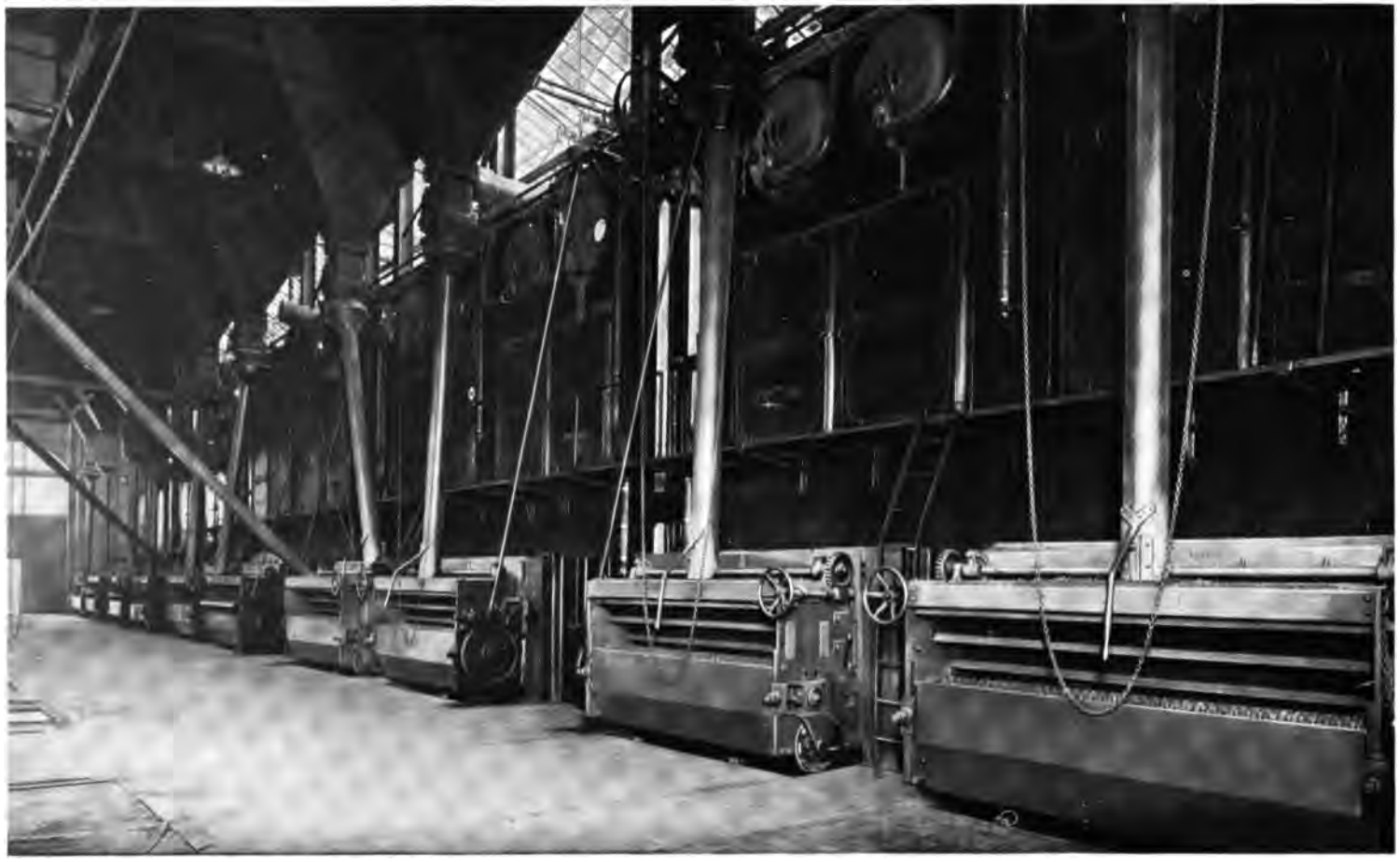

PUBLIC SERVICE CO., OF NORTHERN ILLINOIS, BLUE ISLAND, ILL., STATION. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 9600 HORSE POWER OF BABCOCK & WILCOX BOILERS. THIS COMPANY OPERATES IN ITS VARIOUS STATIONS 14,600 HORSE POWER OF BABCOCK & WILCOX BOILERS AND CHAIN GRATE STOKERS

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most carefully. This is particularly true where the boiler is of a type which requires combustion arches in the furnace.

All fire brick should be dry when used and protected from moisture until used. Each brick should be dipped in a thin fire-clay wash, "rubbed and shoved" into place, and tapped with a wooden mallet until it touches the brick next below it. It must be recognized that fire clay is not a cement and that it has little or no holding power. Its action is that of a filler rather than a binder and no fire-clay wash should be used which has a consistency sufficient to permit the use of a trowel.

All fire-brick linings should be laid up four courses of headers and one stretcher. Furnace center walls should be entirely of fire brick. If the center of such walls is built of red brick, they will often melt down and cause the failure of the wall as a whole.

Fire-brick arches should be constructed of selected brick which are smooth, straight and uniform. The forms on which such arches are built, called arch centers, should be constructed of batten strips not over 2 inches wide. The brick should be laid on these centers in courses, not in rings, each joint being broken with a bond equal to the length of half a brick. Each course should be first tried in place dry, and checked with a straight edge to insure a uniform thickness of joint between courses. Each brick should be dipped on one side and two edges only and tapped into place with a mallet. Wedge brick courses should be used only where necessary to keep the bottom faces of the straight brick course in even contact with the centers. When such contact cannot be exactly secured by the use of wedge brick, the straight brick should lean away from the center of the arch rather than toward it. When the arch is approximately two-thirds completed, a trial ring should be laid to determine whether the key course will fit. When some cutting is necessary to secure such a fit, it should be done on the two adjacent courses on the side of the brick away from the key. It is necessary that the keying course be a true fit from top to bottom, and after it has been dipped and driven it should not extend below the surface of the arch, but preferably should have its lower edge ¼ inch above this surface. After fitting, the keys should be dipped, replaced loosely, and the whole course driven uniformly into place by means of a heavy hammer and a piece of wood extending the full length of the keying course. Such a driving in of this course should raise the arch as a whole from the center. The center should be so constructed that it may be dropped free of the arch when the key course is in place and removed from the furnace without being burned out.

Relation of Draft to Setting Brickwork—The bearing that the draft available has upon the boiler setting and particularly the furnace setting is a factor that, in general, has only recently been given its proper consideration. Such a relation is to be distinguished from that of draft and combustion rates.

The draft available should be such as to provide a suction throughout all parts of the boiler setting at all times and under all conditions of operation.

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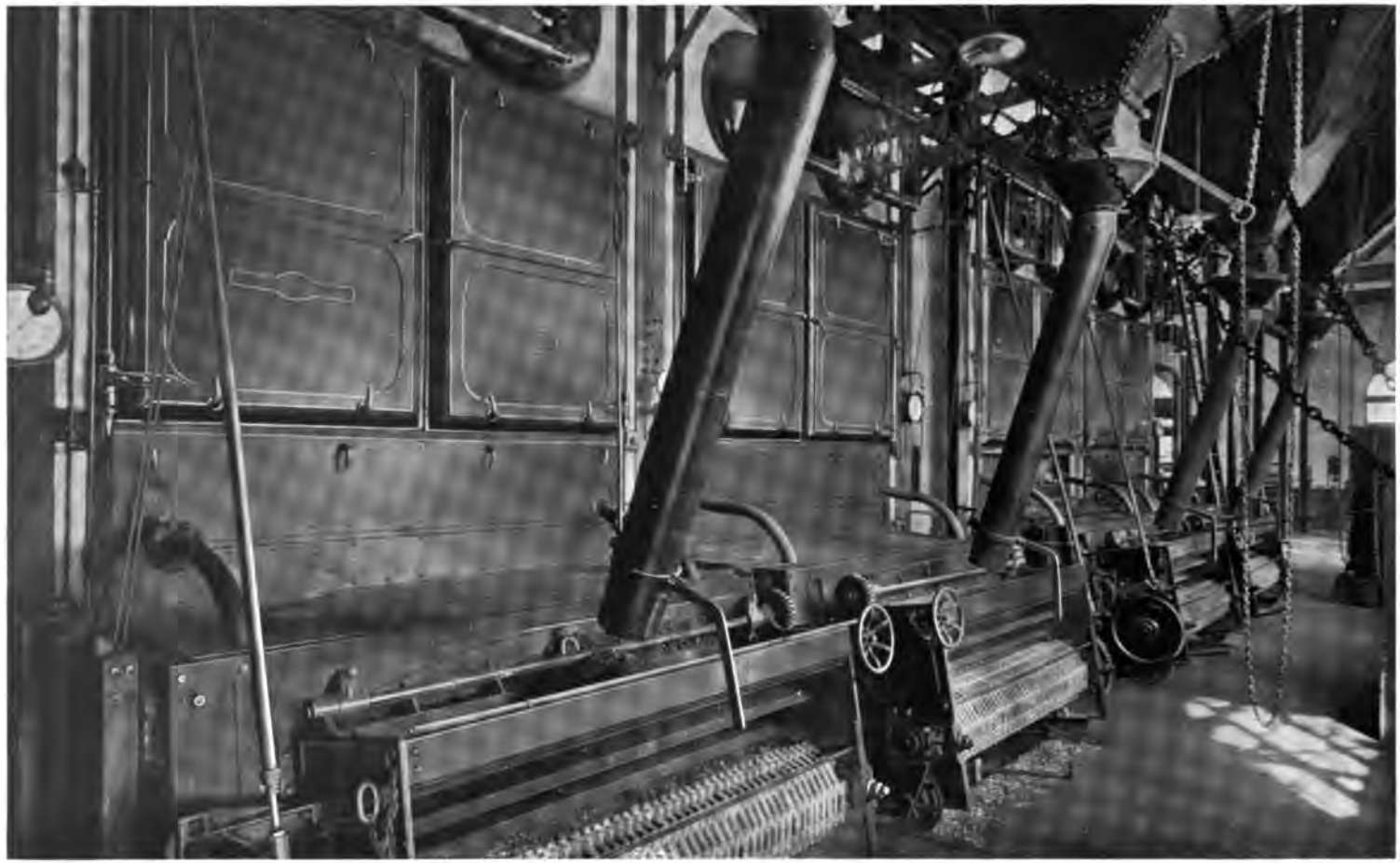

PENNSYLVANIA TUNNEL AND TERMINAL RAILROAD CO., SUNNYSIDE PLANT, LONG ISLAND CITY, N. Y.
BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 2000 HORSE POWER OF
BABCOCK & WILCOX BOILERS

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Where such a suction does not exist and a back pressure is found at any point in the setting, there is a tendency to force the gases of combustion outward through the boiler setting and to overheat the brickwork and access and inspection doors. This overheating, which will increase as the gases are hotter or as the boiler furnace is approached, will naturally cause a rapid deterioration of the setting and warping of the doors and frames. Where the products of combustion are not carried away from the boiler furnace and through the setting by an ample draft suction, the cost of upkeep of the setting will be excessive and will be greatest where such a suction does not exist in the boiler furnace. Here the highest temperatures are found and if the hot gases are not removed promptly, the "soaking up" of the heat by the furnace walls and arches cannot but be harmful from the standpoint of length of life.

With a natural draft stoker, the fact that there is sufficient draft in the furnace to burn the necessary amount of coal to develop the rating at which a boiler is being operated is ordinarily a safe indication that there is a draft suction throughout all parts of the setting and that the gases are being properly carried away from the furnace. This statement, of course, refers to those instances in which there is no undue loss in draft in passing from the furnace proper to the point at which the gases encounter the boiler heating surface.

With forced draft stokers, on the other hand, the blast is ordinarily relied upon to give the required combustion rates. With this class of apparatus, therefore, the function of the stack is simply to remove the products of combustion from the furnace and it is in such cases that the question of suction throughout *all* parts of the setting is to be watched.

It may be readily conceived and, in fact, the condition is frequently found in practice, that a draft suction in the boiler furnace does not necessarily indicate that such a suction exists throughout all parts of the setting. For instance, in a boiler with vertical or semi-vertical passes for the gases, a suction may be found in the furnace while at the top of such a pass a slight back pressure may exist. Such condition is due to the effect of the column of heated gases passing upward, which acts in the same way as the gases in a chimney, insofar as providing a draft at the bottom is concerned.

In determining stack sizes for forced draft stokers as for all boiler work, the diameter is a function of the amount of gases to be handled and should be made such as to give no undue frictional resistance to the gases because of insufficient area. The height is purely a function of the draft that must be supplied. With natural draft stokers, as with hand firing, it must be sufficient to provide in the boiler furnace ample draft to give the combustion rate necessary to develop the maximum capacity at which the boiler is to be operated, proper attention being given to losses in draft due to length of flues, turns, resistance offered in the passage through the boiler, etc.

With forced draft stokers the stack height must be such that a draft suction is assured throughout all portions of the setting under all conditions of operation,

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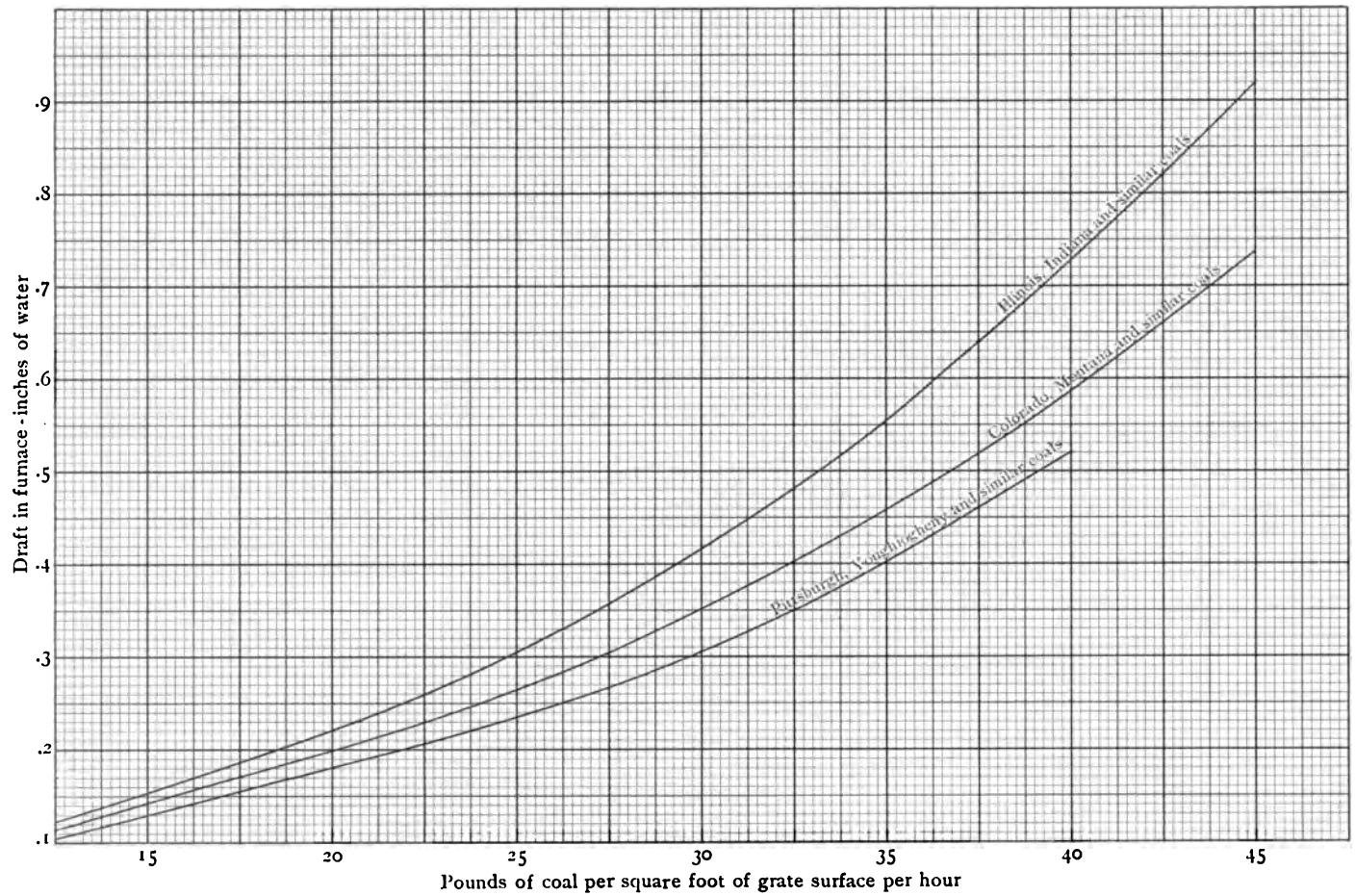

FIG. 1. COMBUSTION RATES WITH CHAIN GRATE STOKERS

COAL PER SQUARE FOOT OF GRATE THAT MAY BE BURNED WITH VARYING AMOUNTS OF DRAFT IN BOILER FURNACE

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regardless of the intensity of the blast supplied to give the necessary combustion rates, and the same attention must be given to factors causing draft losses.

In the early days of forced draft stoker work, manufacturers of this class of apparatus had a tendency to overcarry the mark as far as the reduction in stack sizes was concerned, taking a stand that their product required practically no stack. The importance of furnace and setting upkeep cost, however, is now appreciated by such manufacturers and they are insisting that sufficient stack be provided to maintain a draft suction through the boiler under all conditions.

Fig. 1 shows graphically the draft required in the boiler furnace to give different combustion rates with the various coals which chain grate stokers handle with the most satisfactory results.

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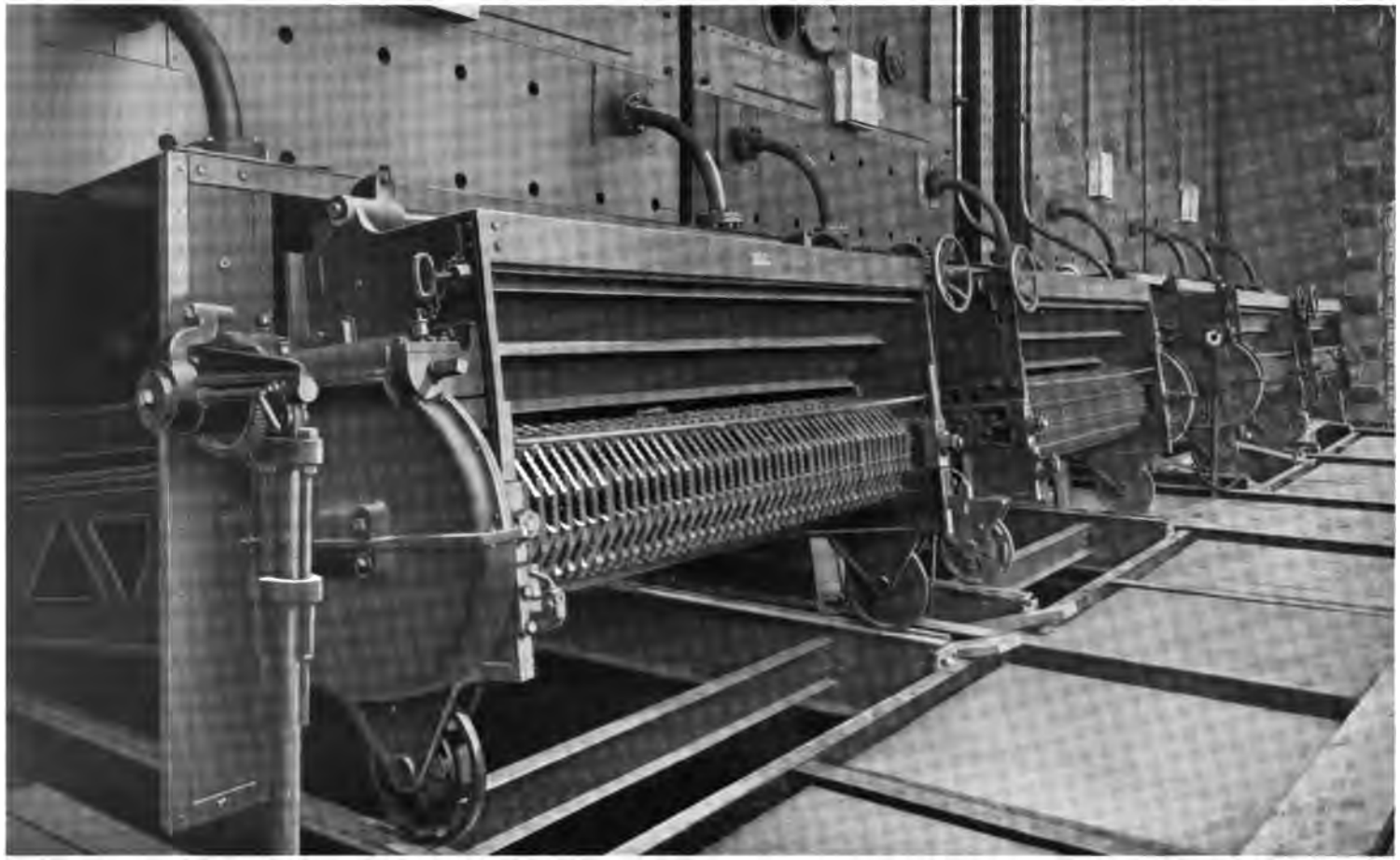

PENNSYLVANIA R. R. CO., PITCAIRN, PA., SHOPS. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 4000 HORSE POWER OF STIRLING BOILERS

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TESTS OF VARIOUS BOILERS EQUIPPED WITH BABCOCK & WILCOX CHAIN GRATE STOKERS

Plant		Commonwealth Edison Co.	Ross Pumping Station	Atlas Portland Cement Co.
Location		Chicago, Ill.	Pittsburgh, Pa.	N'hampton, Pa.
Kind of boiler		B. & W.	A. & T.	B. & W.
Boiler heating surface	sq. ft.	5080	3503	2666
Rated horse power	H. P.	508	350	267
Grate surface	sq. ft.	90	75	651
Bituminous coal from		Illinois	Pennsylvania	Pennsylvania
Mine or trade name		Carterville	Pittsburgh	Beech Creek
Duration of test	hours	7	12	7
Steam pressure by gauge	lbs.	184	151.8	170
Temperature of feed water	°F.	127.1	161.3	127
Degrees of superheat	°F.	180		
Factor of evaporation		1.2393	1.0985	1.1355
Blast under grates	inches			
Draft in furnace	inches	.68		
Draft at boiler damper	inches	1.15	.41	.37
Temperature of escaping gases	°F.	610	440	527
Total water fed to boiler	lbs.	213535	145751	56228
Equivalent evaporation from and at 212°	lbs.	264635	160107	63847
Equivalent evaporation from and at 212° per hour	lbs.	37805	13342	9121
Equivalent evaporation from and at 212° per square foot of heating surface per hour	lbs.	7.43	3.81	3.42
Horse power developed	H. P.	1095.8	386.7	264.2
Per cent of rated horse power developed	%	215.7	110.5	98.9
Total coal fired	lbs.	30610	17850	6716
Per cent of moisture in coal	%	11.12	5.74	2.90
Total dry coal	lbs.	27206	16825	6521
Per cent of ash and refuse	%	14.7	17.78	14.66
Total combustible	lbs.	23198	13833	55.64
Dry coal per square foot of grate surface, per hour	lbs.	43.20	18.70	14.31
Flue gas analysis — CO_2	%	10.4	9.8	
Flue gas analysis — O	%	9.4	8.8	
Flue gas analysis — CO	%	0.2	0.2	
Proximate analysis dry coal — Volatile matter	%		31.38	30.67
Proximate analysis dry coal — Fixed carbon	%		56.29	57.00
Proximate analysis dry coal — Ash	%	10.24	12.33	12.33
B. t. u. per pound of dry coal	B. t. u.	13126	13089	13547
Equivalent evaporation from and at 212° per pound of dry coal	lbs.	9.73	9.52	9.79
Efficiency of boiler and furnace	%	71.9	70.6	70.1

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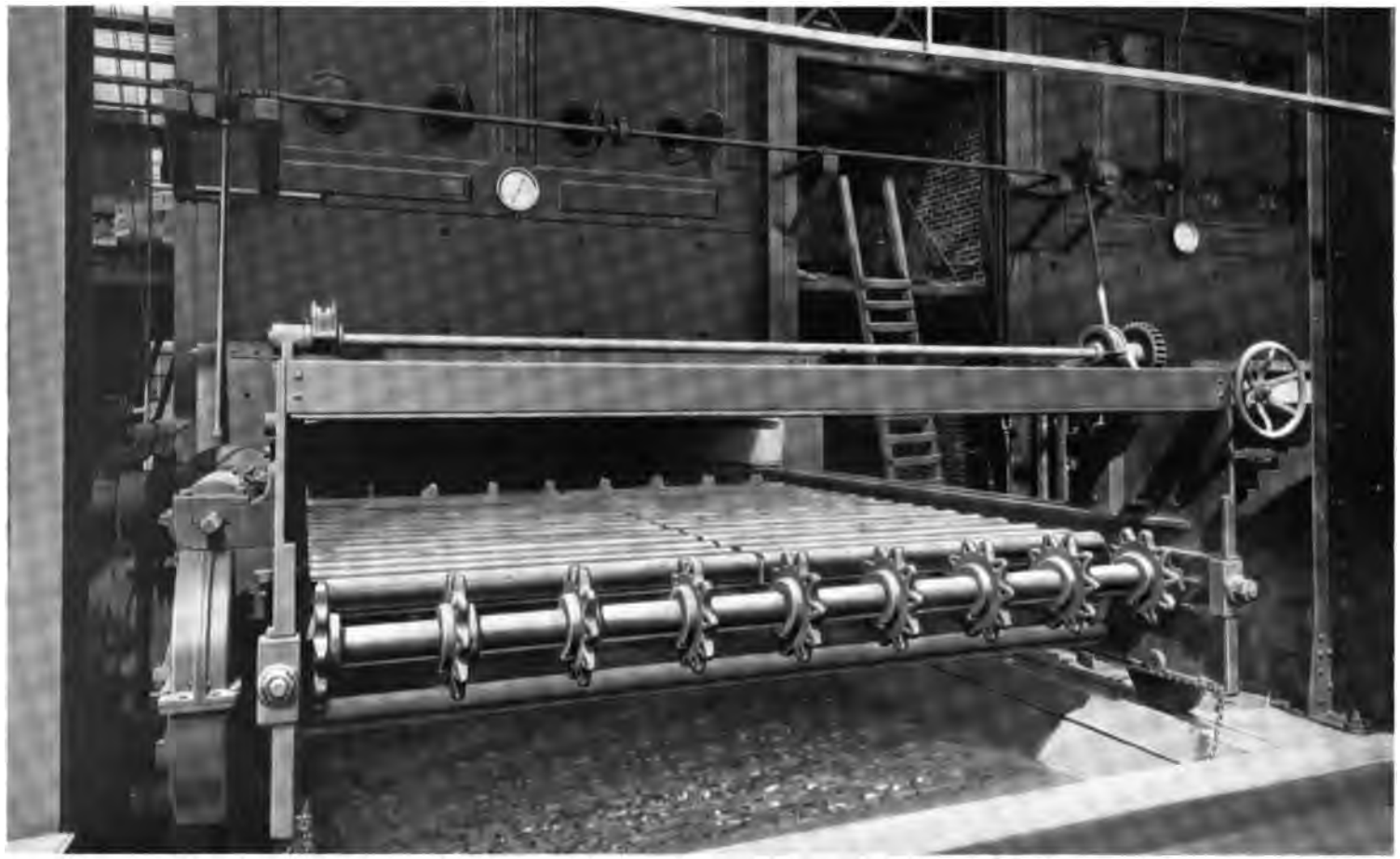

BABCOCK & WILCOX CHAIN GRATE STOKER IN COURSE OF ERECTION SHOWING STOKER BEFORE LINKS ARE IN PLACE

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TESTS OF VARIOUS BOILERS EQUIPPED WITH BABCOCK & WILCOX CHAIN GRATE STOKERS

Plant		Union El. Lt. & Power Co.	Union El. Lt. & Power Co.	Babcock & Wilcox Co.
Location		St. Louis, Mo.	St. Louis, Mo.	Barberton, O.
Boiler		B. & W.	B. & W.	Stirling
Heating surface of boiler	sq. ft.	5080	5080	11279
Rated horse power	H. P.	508	508	1128
Grate surface	sq. ft.	103.5	103.5	187
Bituminous coal from		St. Clair Co., Ill.	St. Clair Co., Ill.	Pennsylvania
Mine or trade name		Mascouth	Mascouth	Pittsburgh
Duration of test	hours	8	8	8
Steam pressure by gauge	lbs.	180	183	132
Temperature of feed water	°F.	46	53	109
Degrees of superheat	°F.	113	104	152
Factor of evaporation		1.281	1.2725	1.2352
Blast under grates	inches	. . . .	. . . .	1.09
Draft in furance	inches	.62	.60	.16
Draft at boiler damper	inches	1.24	1.26	.97
Temperature of escaping gases	°F.	523	567	624
Total water fed to boiler	lbs.	175984	195088	499893
Equivalent evaporation from and at 212°	lbs.	226512	248248	617468
Equivalent evaporation from and at 212° per hour	lbs.	28314	31031	77184
Equivalent evaporation from and at 212° per square foot of heating surface per hour	lbs.	5.67	6.11	6.84
Horse power developed	H. P.	820.4	899.7	2237.2
Per cent of rated horse power developed	%	161.5	177.1	198.3
Total coal fired	lbs.	32163	36150	67292
Per cent of moisture in coal	%	13.74	14.62	3.50
Total dry coal	lbs.	27744	30865	64937
Per cent of ash and refuse	%	. . . .	. . . .	18.29
Total combustible	lbs.	. . . .	. . . .	53060
Dry coal per square foot of grate surface per hour	lbs.	33.50	37.28	43.41
Flue gas analysis — CO_2	%	8.7	8.9	11.2
Flue gas analysis — O	%	10.6	10.7	8.3
Flue gas analysis — CO	%	0.0	0.2	0.0
Proximate analysis dry coal — Volatile matter	%	28.96	36.50	31.35
Proximate analysis dry coal — Fixed carbon	%	46.88	41.20	52.71
Proximate analysis dry coal — Ash	%	24.16	22.30	15.94
B. t. u. per pound of dry coal	B. t. u.	10576	10849	12130
Equivalent evaporation from and at 212° per pound of dry coal	lbs.	8.16	8.04	9.51
Efficiency of boiler and furnace	%	74.9	71.9	76.1

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COMMONWEALTH EDISON CO., CHICAGO, ILL., QUARRY STREET STATION. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 24,400 HORSE POWER OF BABCOCK & WILCOX BOILERS

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TESTS OF VARIOUS BOILERS EQUIPPED WITH BABCOCK & WILCOX CHAIN GRATE STOKERS

Plant		Washington Terminal Co.	Washington Terminal Co.	Tiffin Electric Co.
Location		Washington D. C.	Washington D. C.	Tiffin, Ohio.
Boiler		B. & W.	B. & W.	A. & T.
Heating surface of boiler	sq. ft.	4220	4220	3935
Rated horse power	H. P.	422	422	400
Grate surface	sq. ft.	85	85	64
Bituminous coal from		Somerset Co. Pa.	Westmoreland Co., Pa.	Ohio
Mine or trade name		Jenner	Westmoreland	Coshocton
Duration of test	hours	8	8	8
Steam pressure by gauge	lbs.	156.6	158.2	110
Temperature of feed water	°F.	225.6	234.5	75
Degrees of superheat	°F.	90.2	92.4	
Factor of evaporation		1.0862	1.0783	1.1822
Blast under grates	inches			
Draft in furnace	inches			.31
Draft at boiler damper	inches	.45	.58	.43
Temperature of escaping gases	°F.	443	456	467
Total water fed to boiler	lbs.	163834	166383	108688
Equivalent evaporation from and at 212°	lbs	177356	179411	128491
Equivalent evaporation from and at 212° per hour	lbs.	22169	22426	16061
Equivalent evaporation from and at 212° per square foot of heating surface per hour	lbs.	5.25	5.31	4.08
Horse power developed	H. P.	642.6	650.0	465.5
Per cent of rated horse power developed	%	152.3	154.0	116.4
Total coal fired	lbs.	18050	19225	15000
Per cent of moisture in coal	%	7.11	8.66	6.01
Total dry coal	lbs.	16767	17560	14099
Per cent of ash and refuse	%	17.71	15.47	19.90
Total combustible	lbs.	13798	14843	11294
Dry coal per square foot of grate surface per hour	lbs.	24.46	25.82	27.53
Flue gas analysis — CO_2	%	13.45	10.30	10.6
Flue gas analysis — O	%	5.40	9.19	9.4
Flue gas analysis — CO	%	0.41	0 00	0.0
Proximate analysis dry coal — Volatile matter	%	13.58	31.65	33.65
Proximate analysis dry coal — Fixed carbon	%	78.00	57.71	52.01
Proximate analysis dry coal — Ash	%	7.42	10.64	14.34
B. t. u. per pound of dry coal	B. t. u.	14451	13580	12131
Equivalent evaporation from and at 212° per pound of dry coal	lbs.	10.58	10.02	9.11
Efficiency of boiler and furnace	%	71.0	71.6	72.8

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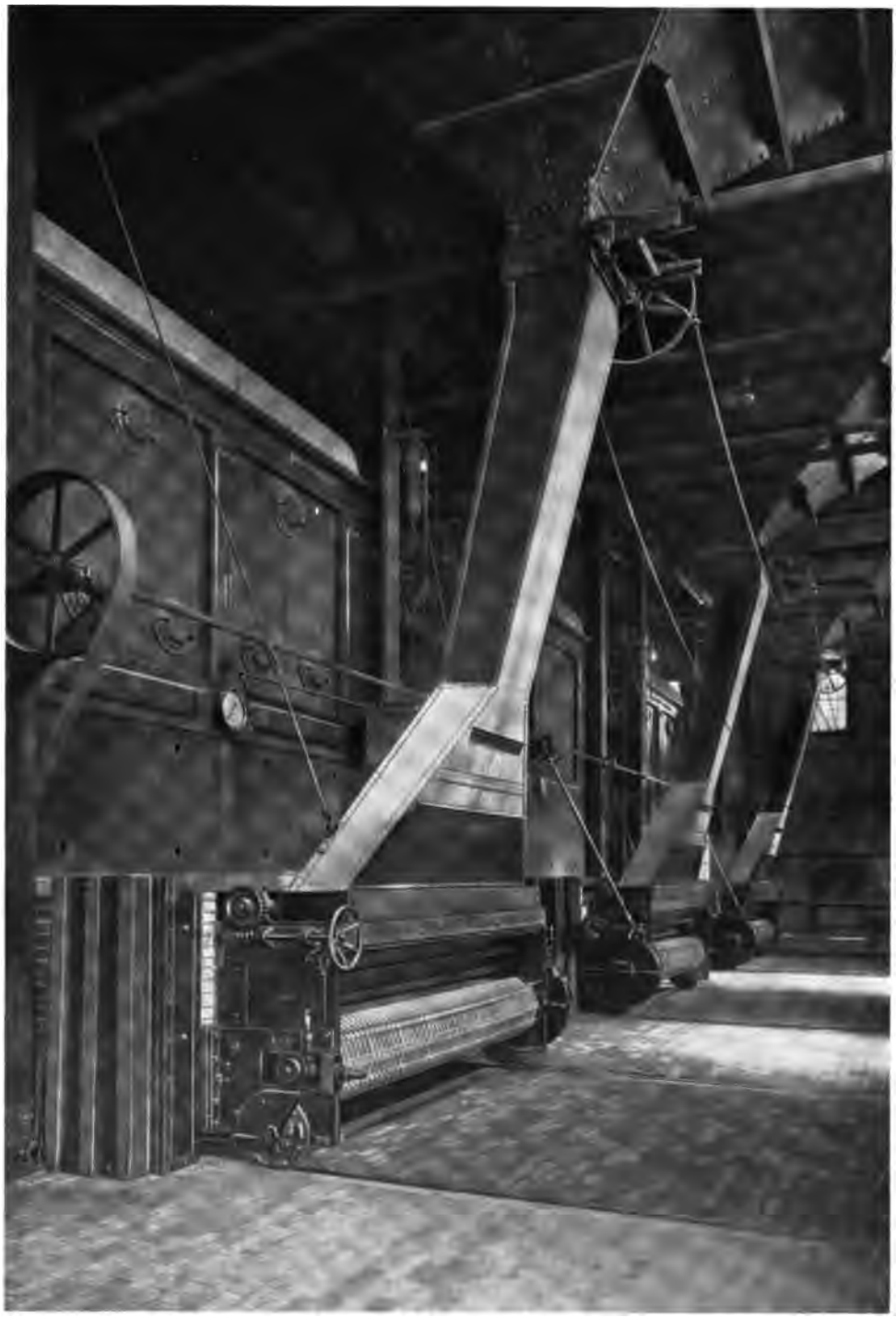

NEWPORT ROLLING MILL CO., NEWPORT, KY. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 1530 HORSE POWER OF STIRLING BOILERS

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TESTS OF VARIOUS BOILERS EQUIPPED WITH BABCOCK & WILCOX CHAIN GRATE STOKERS

Plant		Erie County Electric Co.	Public Service Corp. of N. J.	Public Service Corp. of N. J.
Location		Erie, Pa.	Marion, N. J.	Marion, N. J.
Kind of boiler		A. & T.	B. & W.	B. & W.
Boiler heating surface	sq. ft.	5080	6000	6000
Rated horse power	H. P.	508	600	600
Grate surface	sq. ft.	90	132	132
Bituminous coal from		Mercer Co., Pa.	Pennsylvania	Pennsylvania
Mine or trade name		Taylor Vein	Lancashire	Lincoln
Duration of test	hours	8	8	8
Steam pressure by gauge	lbs.	120	200	199
Temperature of feed water	°F.	69.9	57.2	60.7
Degrees of superheat	°F.		280.4	171.7
Factor of evaporation		1.1888	1.3909	1.3191
Blast under grates	inches		.52	.15
Draft in furnace	inches	.31		.04
Draft at boiler damper	inches	.58	.52	.52
Temperature of escaping gases	°F.	533	590	529
Total water fed to boiler	lbs.	166072	231248	184592
Equivalent evaporation from and at 212°	lbs.	197424	321640	243496
Equivalent evaporation from and at 212° per hour	lbs.	24678	40205	30437
Equivalent evaporation from and at 212° per square foot of heating surface per hour	lbs.	4.85	6.70	5.07
Horse power developed	H. P.	715.3	1165.2	882.0
Per cent of rated horse power developed	%	140.8	194.2	147.0
Total coal fired	lbs.	22328	32205	24243
Per cent of moisture in coal	%	4.42	4.03	4.09
Total dry coal	lbs.	21341	30907	23251
Per cent of ash and refuse	%	16.88	15.65	12.33
Total combustible	lbs.	17739	26070	20385
Dry coal per square foot of grate surface per hour	lbs.	29.64	29.26	22.01
Flue gas analysis — CO_2	%	10.1	10.5	10.1
Flue gas analysis — O	%	9.1	8.3	9.0
Flue gas analysis — CO	%	0.0	0.0	0.0
Proximate analysis dry coal — Volatile matter	%	33.26	22.84	32.36
Proximate analysis dry coal — Fixed carbon	%	54.03	69.91	60.67
Proximate analysis dry coal — Ash	%	12.71	7.25	6.97
B. t. u. per pound of dry coal	B. t. u.	12742	13840	14027
Equivalent evaporation from and at 212° per pound of dry coal	lbs.	9.25	10.41	10.47
Efficiency of boiler and furnace	%	70.4	72.6	72.1

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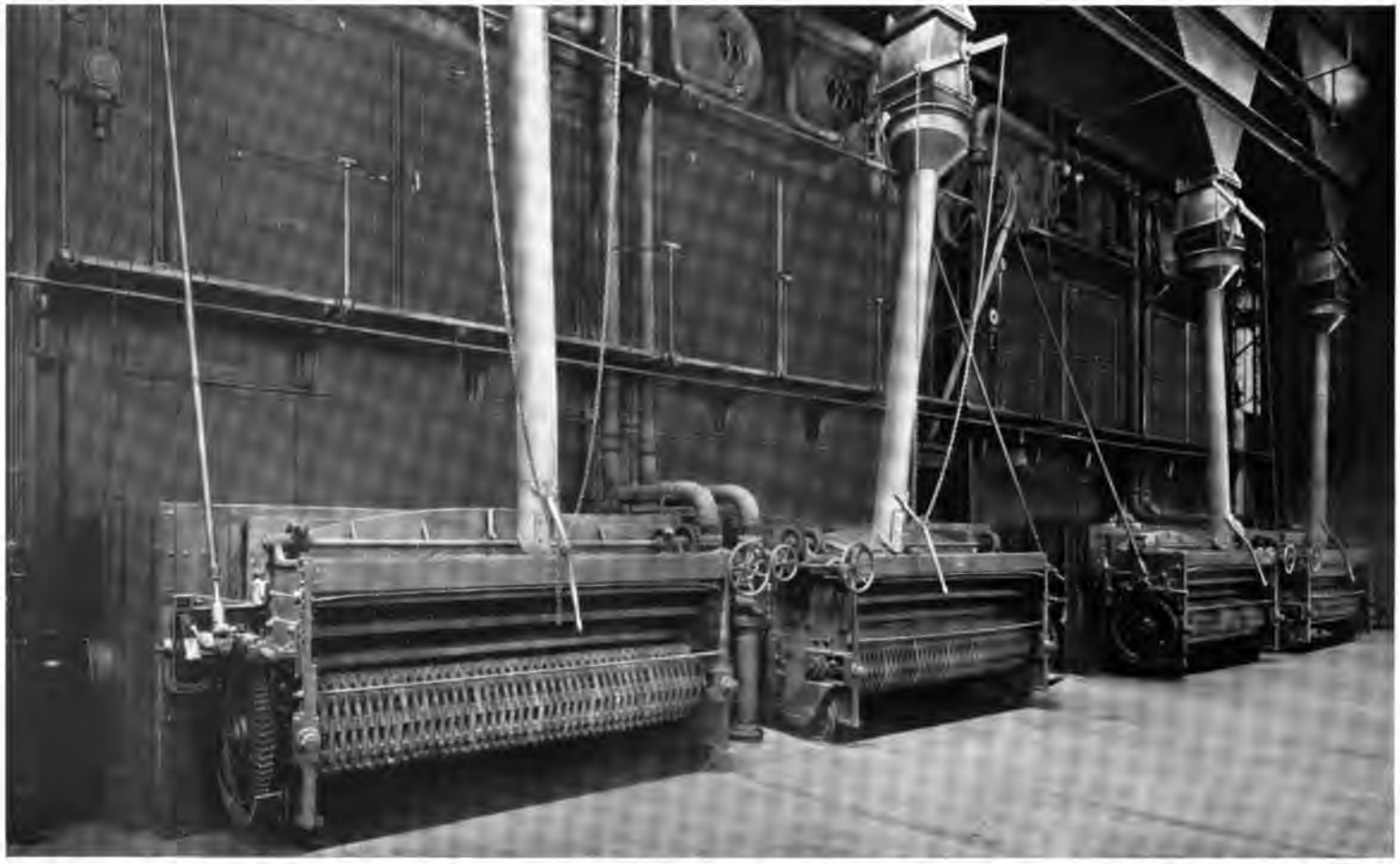

LOUISVILLE GAS & ELECTRIC CO., LOUISVILLE, KY. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED IN 4000 HORSE POWER OF BABCOCK & WILCOX BOILERS

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TWIN CITY RAPID TRANSIT CO., MINNEAPOLIS, MINN. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 15,400 HORSE POWER OF BABCOCK & WILCOX BOILERS

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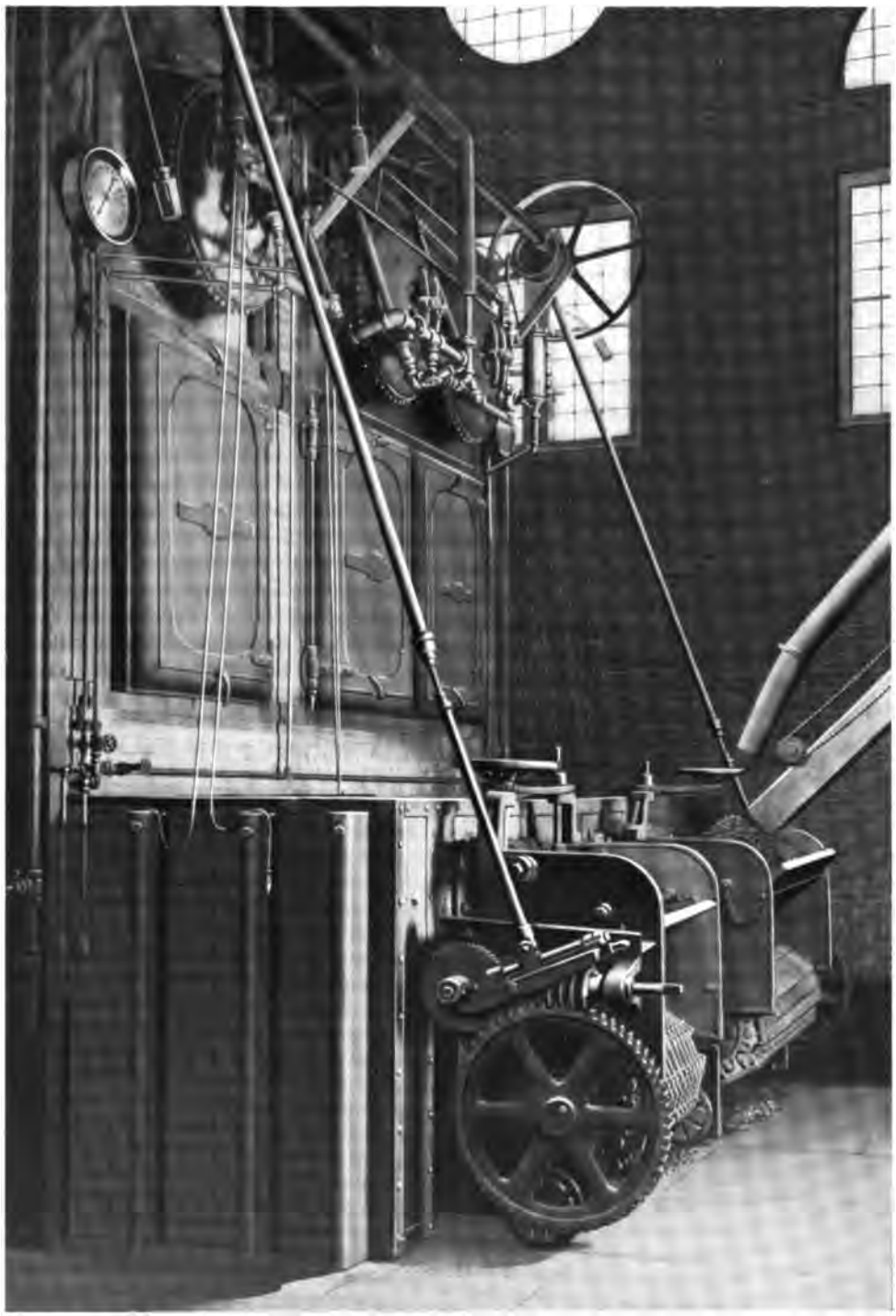

COLORADO SCHOOL OF MINES, GOLDEN, COL. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 300 HORSE POWER OF BABCOCK & WILCOX BOILERS

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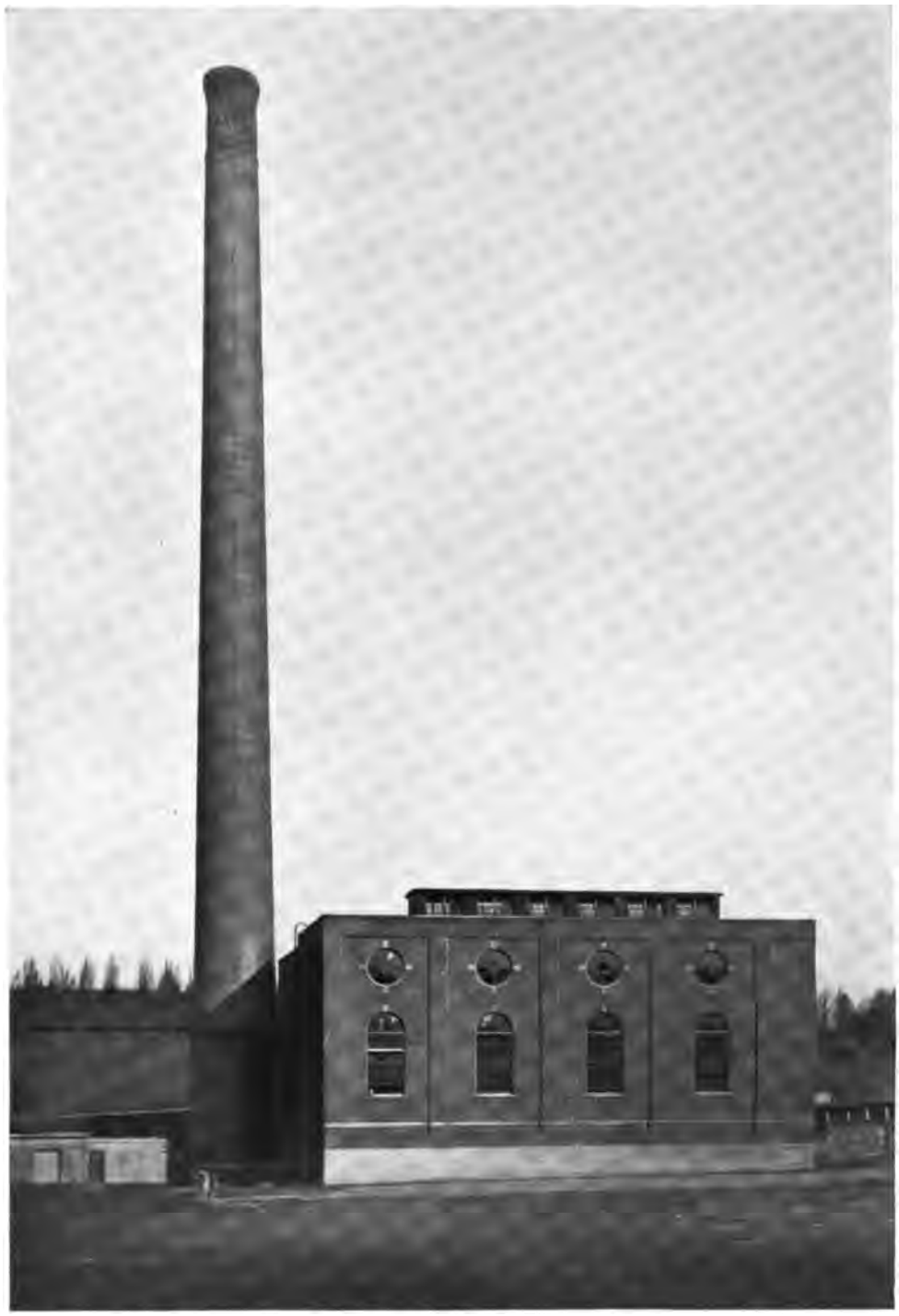

ERIE COUNTY ELECTRIC CO., ERIE, PA. OPERATING BABCOCK & WILCOX CHAIN GRATE STOKERS IN CONNECTION WITH 3100 HORSE POWER OF BABCOCK & WILCOX BOILERS

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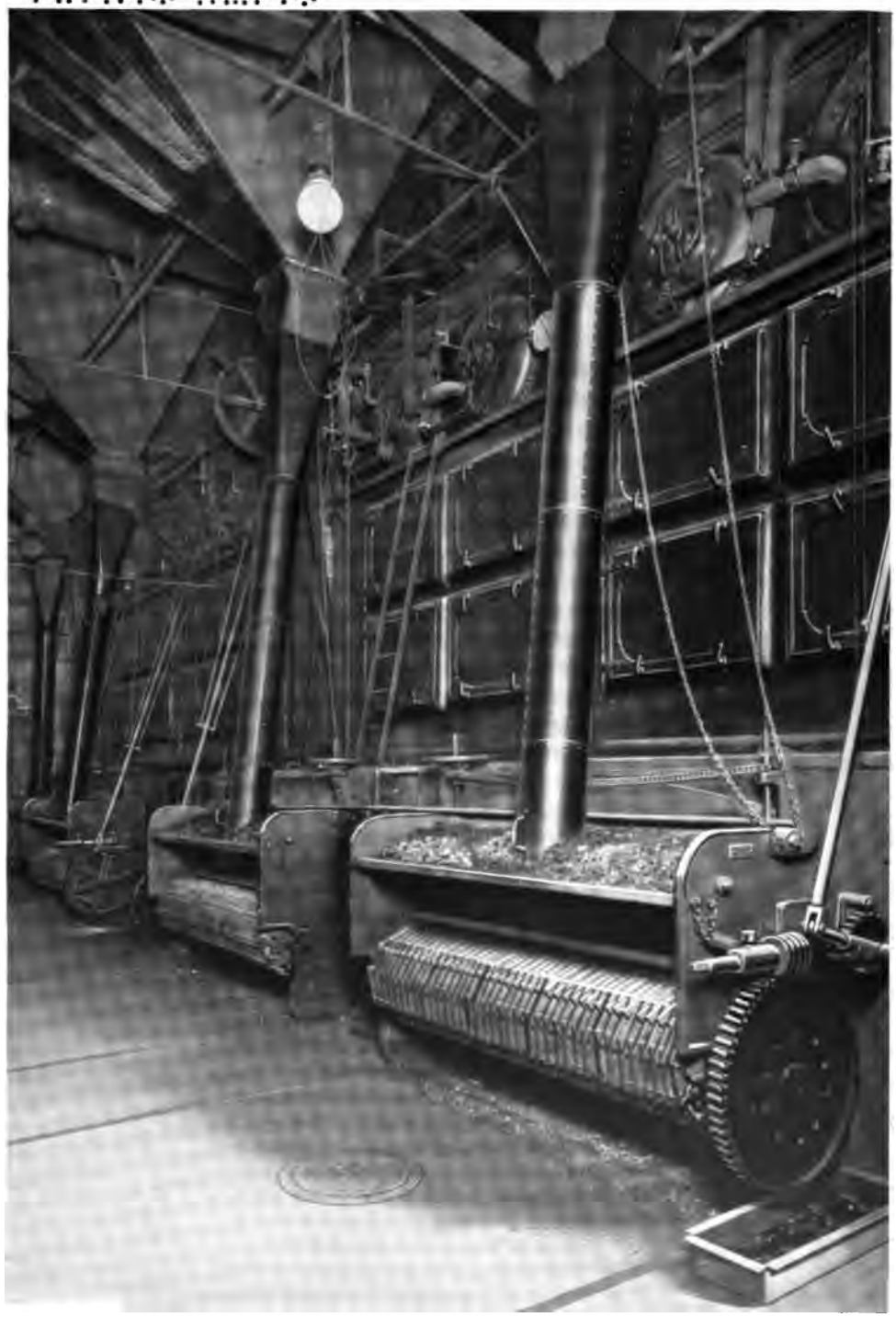

PETER SCHOENHOFEN BREWING CO., CHICAGO, ILL. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 2600 HORSE POWER OF BABCOCK & WILCOX BOILERS

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SOUTH SIDE ELEVATED RY. CO., CHICAGO, ILL. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 9900 HORSE POWER OF BABCOCK & WILCOX BOILERS

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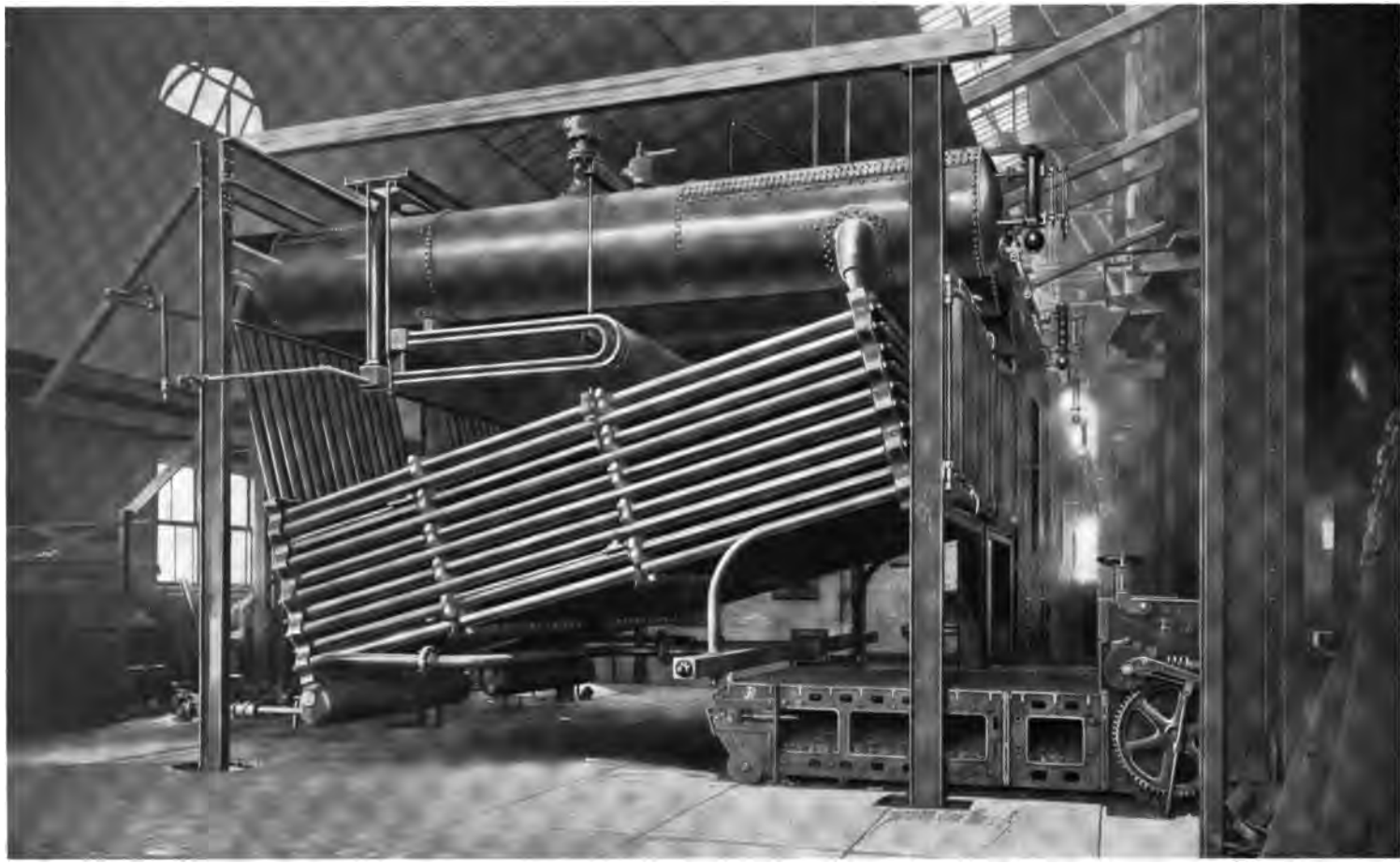

CITY OF CLEVELAND, OHIO, WATER WORKS. BABCOCK & WILCOX CHAIN GRATE STOKER IN COURSE OF ERECTION WITH A BABCOCK & WILCOX BOILER, EQUIPPED WITH SUPERHEATER

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COSMOPOLITAN ELECTRIC CO., CHICAGO, ILL. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 4100 HORSE POWER OF BABCOCK & WILCOX BOILERS

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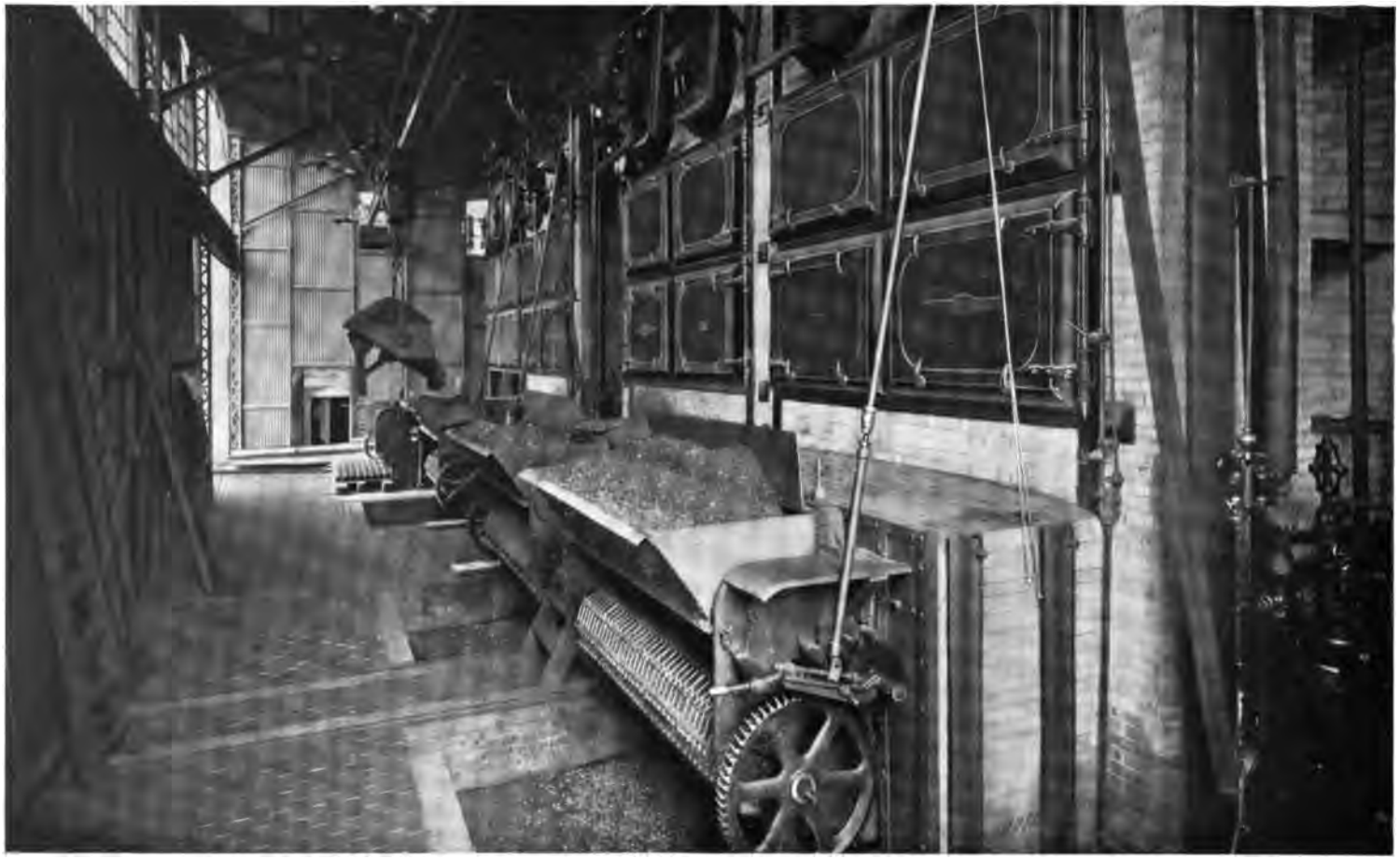

CLEVELAND HARDWARE CO., CLEVELAND, OHIO. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 2300 HORSE POWER OF BABCOCK & WILCOX BOILERS

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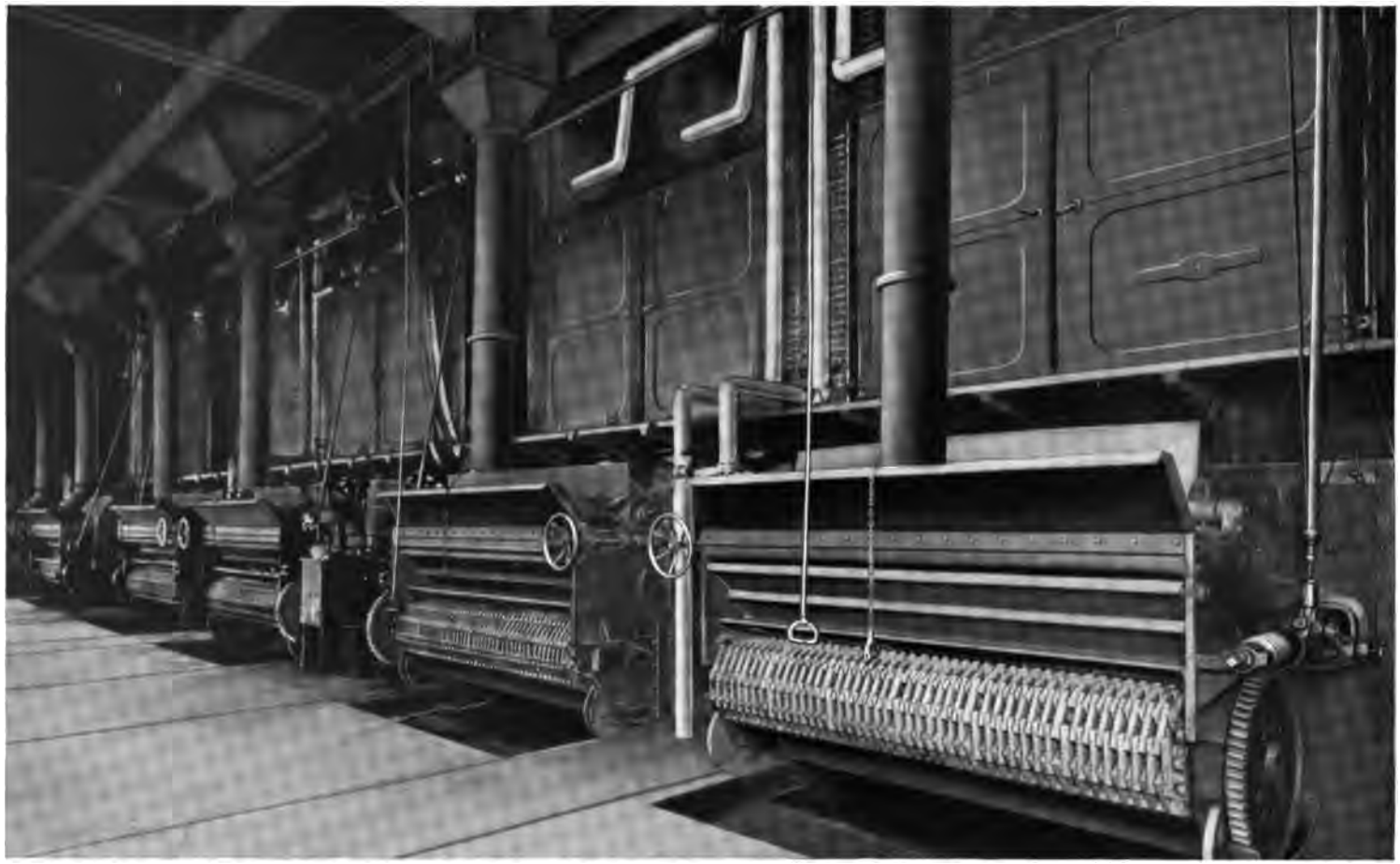

LOUISVILLE RAILWAY CO., LOUISVILLE, KY., CAMPBELL STREET PLANT. THIS COMPANY HAS BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 14,000 HORSE POWER OF BABCOCK & WILCOX BOILERS 6100 HORSE POWER BEING IN THIS STATION

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METROPOLITAN WEST SIDE ELEVATED RY. CO., CHICAGO, ILL. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 7800 HORSE POWER OF BABCOCK & WILCOX BOILERS

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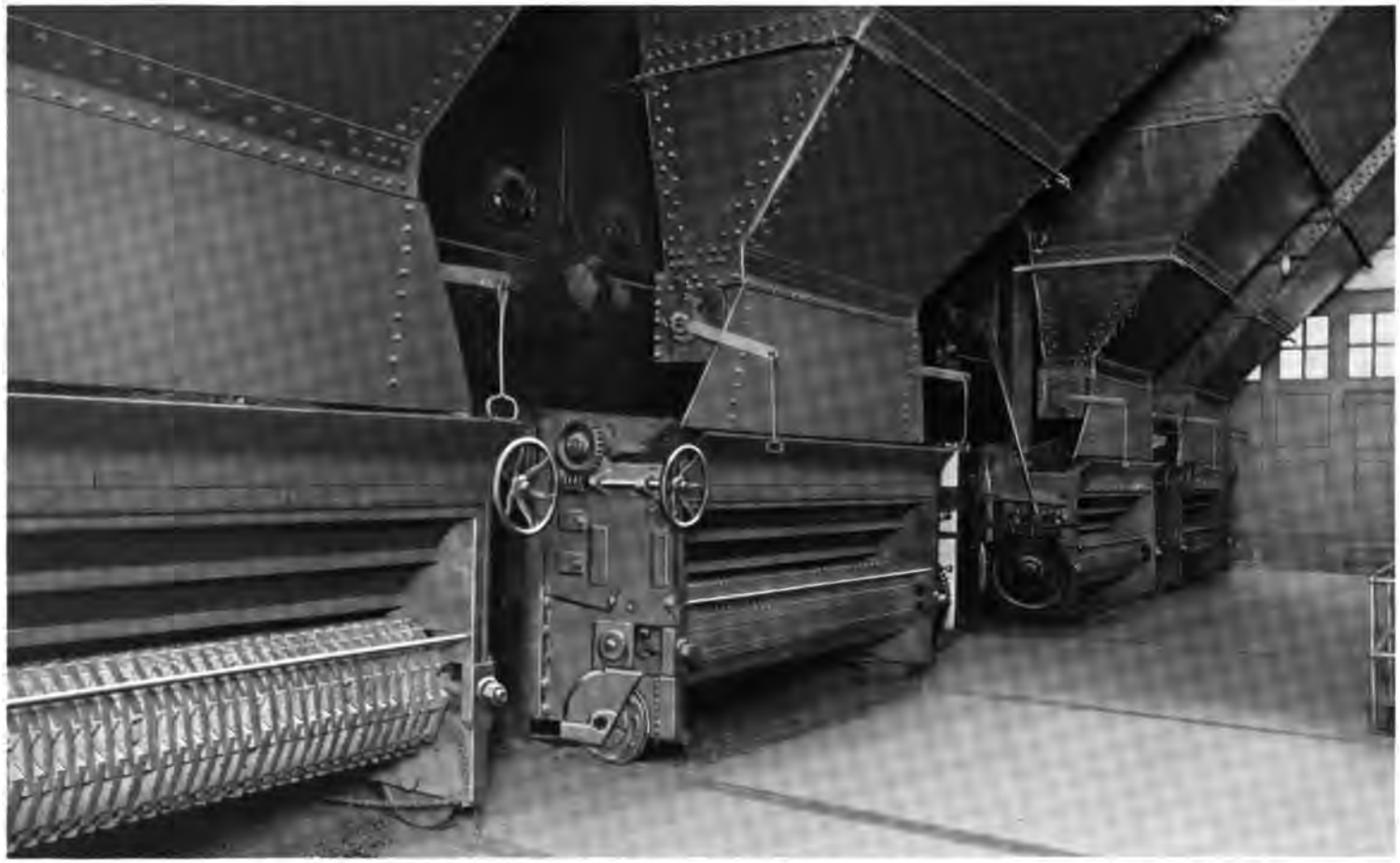

PUBLIC SERVICE CO., OF NORTHERN ILLINOIS, OAK PARK, ILL., STATION. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 2050 HORSE POWER OF STIRLING BOILERS

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COMMONWEALTH EDISON CO., CHICAGO, ILL., NORTHWEST STATION. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 17,500 HORSE POWER OF BABCOCK & WILCOX BOILERS

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S. KARPEN & BROTHERS, CHICAGO, ILL. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 900 HORSE POWER OF STIRLING BOILERS

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ATLAS PORTLAND CEMENT CO., NORTHAMPTON, PA., PLANT. BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 11,000 HORSE POWER OF BABCOCK & WILCOX BOILERS

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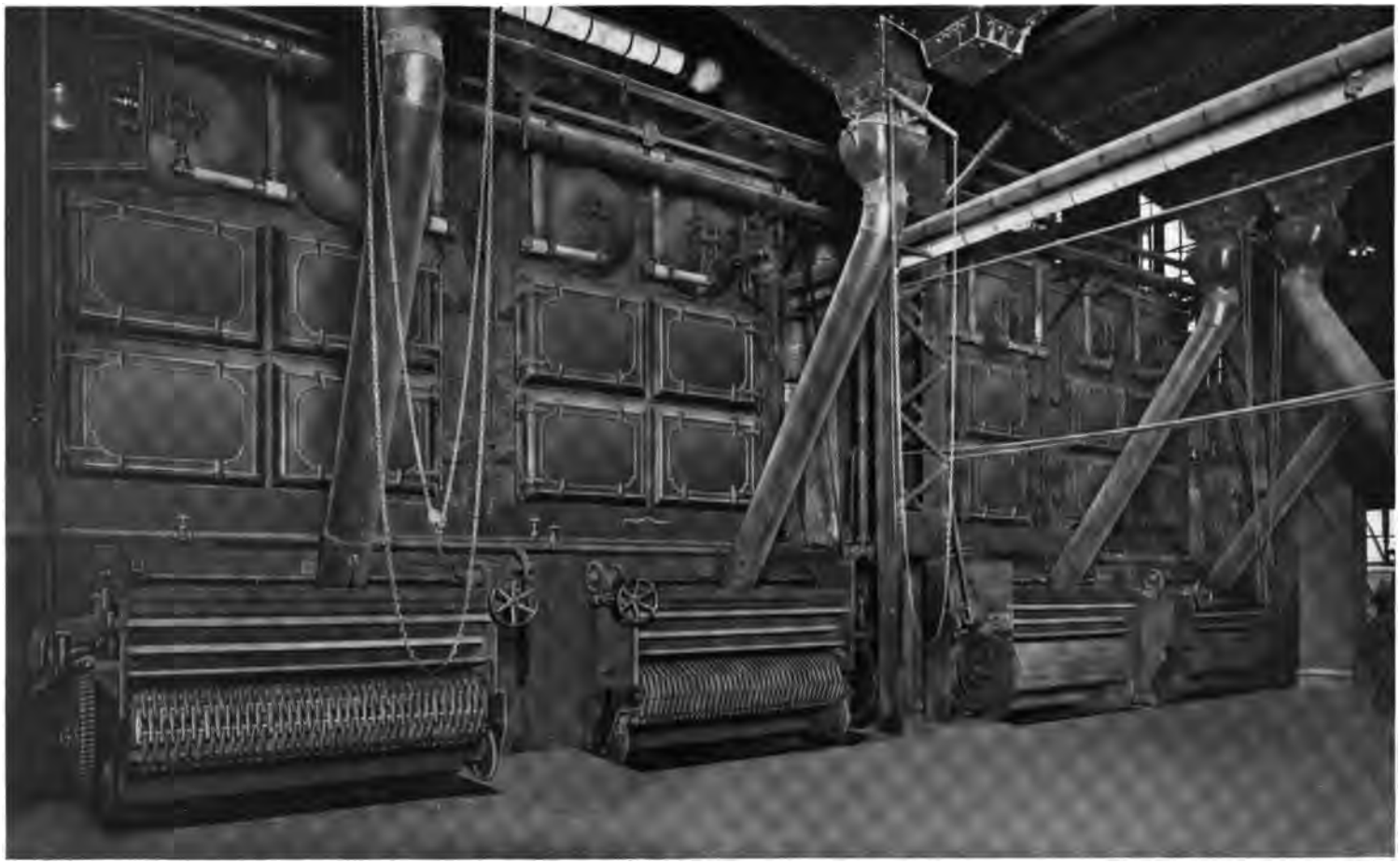

PEOPLE'S GAS LIGHT & COKE CO., CHICAGO, ILL., LOOMIS STREET PLANT. THIS COMPANY HAS BABCOCK & WILCOX CHAIN GRATE STOKERS INSTALLED WITH 6000 HORSE POWER OF BABCOCK & WILCOX BOILERS 3600 HORSE POWER BEING IN THIS STATION

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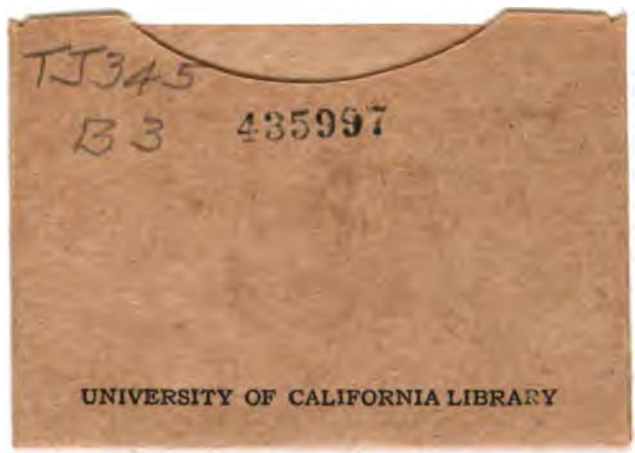
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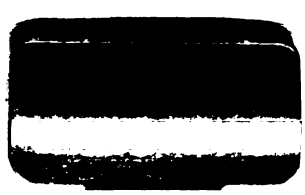

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